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Containing Papers Read Before the 189th Meeting of The Southern Surgical Association

Pinehurst, N. C., December 9, 10, 11, 1941

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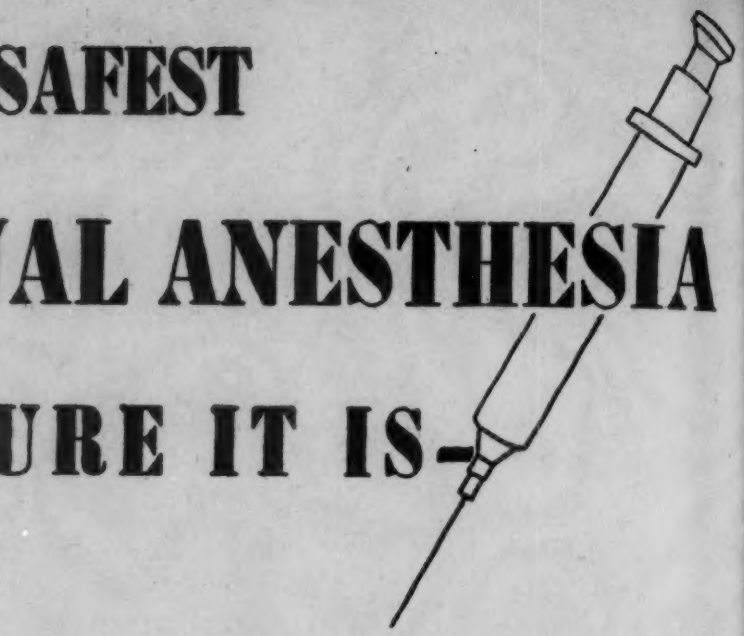

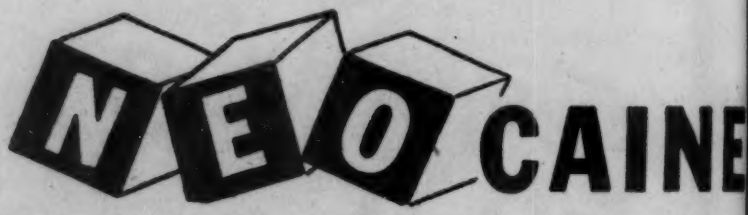

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ANNALS OF SURGERY

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TRANSACTIONS

OF THE

SOUTHERN SURGICAL ASSOCIATION

MEETING HELD AT PINEHURST, N. C.

DECEMBER 9, 10, 11, 1941

ADDRESS OF THE PRESIDENT

"ONCE AGAIN"*

HARRY HYLAND KERR, M.D., C.M.

WASHINGTON, D. C.

TWENTY-THREE YEARS AGO, in 1917, the thirtieth meeting of the Southern Surgical Association was held in St. Augustine, Fla., under the brilliant leadership of the late Dr. William D. Haggard. In his Presidential Address, Doctor Haggard, with his great gift of oratory, called the Medical Profession and the Southern Surgical Association to arms in the First World War that he glowingly described as one of the "most magnificent events in all history." With what stirring words he pictured the glorious part our country was taking in that historic event—with no selfish ambitions of territory or power, we were hurling our mighty strength on the side of Democracy. He paid a glowing tribute to our World War President, whom he described as "that glorious seer, that incomparable patriot, and immortal statesman, Woodrow Wilson, Prime Minister of the World."

Doctor Haggard painted with eloquent words the exalted rôle the United States was to play in the future of the world. He said: "The pages on which the history of this most holy of wars will yet be written will be illuminated with the great white light of our pure and sustained desire to benefit the cause of humanity." "If our nation lives up to its plighted word it will gain for itself new honor and imperishable fame."

In the World War the United States trained, equipped, and sent overseas an army of 2,000,000 men to throw the balance of power in favor of the Allies,

* Presented before the Southern Surgical Association, Pinehurst, N. C., December 9–11, 1941.

and bring the carnage to an end. Then the United States, through its President, who personally attended the Peace Conference, practically forced an agreement among nations for mutual protection and mutual benefits—the League of Nations.

It seemed at that time that, indeed, we had made the world safe for Democracy, and we had fought the last great war to end wars.

But selfish and myopic interests arose in this country to defeat the plans of peace. The League of Nations was emasculated by our refusal to assume our proper place at the Conference Table. The plan was doomed to failure because the United States, the only solvent nation on earth, basely turned its back on the very League of Nations that it had forced upon the Peace Conference. We were the great creditor nation of the world. The other nations had been bled white of their most precious blood and all their liquid capital. They were devastated economically. They all owed us huge sums of money that they had borrowed to stem the advance of autocracy. They could not pay in cash, and we made it impossible for them to pay in kind.

We raised insurmountable tariff barriers so that the product of their labor could not be sold in this country. The natural place we should have assumed in the vanguard of the rehabilitation and reconstruction of war-torn Europe was but a gesture. True, we later advanced further huge sums, not only to our late Allies, but to Germany, smarting under her defeat and weighted down with unpayable reparations. What part of this money went indirectly for preparation for the present war is uncertain.

It was only natural that Europe, stewing in its poverty, should fall victim to the demagogue. He raised their hopes of salvation; he put them to work; and then organized them for war. His very success at the beginning begat a need for more success. He cast his eyes abroad for those natural resources that his own country lacked. He began a campaign of expansion. When this had been accomplished by treachery, lying, and perfidious practices, when one defenseless nation after another had been crushed under the tyrant's heel, the world was again faced by the same problem as in 1914. All the liberties and all the freedom that man had struggled for since the Renaissance were again threatened. From the muck of devastation of the World War arose this monster bent on supreme domination of the world, and on placing the German nation in command, and all other nations in vassalage.

From the perspective of nearly a quarter of a century, we can now look back on those stirring times with critical eyes. The world again is in the throes of a mighty holocaust of war; again, autocracy raises its selfish might to rob the human race of all its hard-won liberties, again, the freedom of the individual is threatened, and again we answer the call of our brother man and advance to his aid.

Can we not gain some knowledge by studying our successes and failures of that time?

To the Medical World of our country, war came, in 1917, as an unforeseen, unpredicted and unprepared-for calamity. To the credit of our then

Surgeon-General, William C. Gorgas, be it said that the tremendous task of organizing the Medical Corps of the Army was brilliantly and successfully accomplished. Our boys were well taken care of. The records of the Medical Corps compare favorably with the accomplishments of all other combatants. No soldiers in all history have been better treated.

The record of the evacuation service, of the evacuation hospitals, and of the base hospitals in France is a magnificent one. The medical profession had responded nobly to the call, and those who had been assigned duty with the A.E.F. acquitted themselves splendidly. Unfortunately, when the need was greatest for medical men overseas, there were several thousand medical officers undergoing military training at Fort Oglethorpe, Ga. Surely, it is not necessary for the army surgeon to learn to drill unless he is assigned to troops. At the Medical Field Service School facilities have been established to train 500 student officers every two months. Refresher courses in administration and special professional courses for reserve officers are given in the permanent general hospitals.

Though the medical men of the A.E.F. did a good job, we can now see how that job could be improved. As the principal function of the medical corps is to maintain the fighting strength, our greatest responsibility is to get the wounded back to their commands as soon as possible. This means rapid and smooth evacuation after proper triage.

As Lyle and Darrach have pointed out, the best interest of the fighting force is served if the effort in the forward area is concentrated on treating the lightly wounded. A superficial wound, properly treated within a few hours, may heal promptly and the soldier soon returned to his outfit. When the effort at the front is concentrated on the seriously wounded, the lightly wounded wait their turn in times of stress, and frequently become so seriously infected that a minor wound becomes a major one. In these forward Evacuation Hospitals capable surgeons, using three or four operating tables each, can turn over 80 to 100 lightly wounded cases in a 12-hour shift.

The use of the new sulfa drugs and their applicability to battle casualties will, no doubt, be an interesting and important development. The first aid kit of every soldier now contains a quantity of sulfapyridine.

The seriously wounded and the so-called nontransportable cases should be evacuated as soon as shock is controlled and the simplest of immediate procedures carried out, such as closing sucking wounds of the chest, preventing possible evisceration, and controlling hemorrhage. To this end special teams are invaluable. Shock teams, transfusion teams, splint teams, *etc.*, amply proved their worth in France.

Evacuation by airplane for the seriously wounded, if practicable at the scene of action, would be ideal for this type of case.

It is evident from the experience of the A.E.F. that major surgical procedures should not be performed in the area of advance. Though it is hazardous to move certain seriously wounded cases, the final results will be better if their surgical treatment can be carried out in a well-equipped, stable base

hospital. Here specialization can be employed to greatest advantage. All the modern and sometimes elaborate equipment for particular types of surgery will be available. And, here again, all the modern developments in postoperative care will be at hand.

Not only were the sick and wounded of the A.E.F. efficiently cared for, but the boys at home got excellent care. The influenza epidemic was devastating, and the mortality high, but the experience of the Army in this catastrophe led to real contributions to our knowledge in the handling of this disease, and particularly the handling of a common complication—empyema.

When the casualties were discharged after the war, a huge bureau of the government was established to take care of them. Their economic as well as their physical welfare was looked after. Medically, the discharged soldier of the U. S. Army has been spoiled to a degree. Not only disabilities incurred in action, but also disease acquired since discharge, are now being treated by the vast Veterans' Administration, with its 91 hospitals and 80,000 beds.

The continued payment of total or partial disabilities to the soldiers has developed a functional element engrafted on their organic disease that can never be eliminated. Thus we are not only paying our wounded soldiers large sums on account of their honorably acquired wounds, but additional large sums for purely neurotic and hysterical manifestations.

At the present time this government has spent $20,000,000,000 on its World War soldiers. The cost *per annum* is now $900,000,000, plus. The Veterans' Administration predicts this sum will increase until 1951, when they will have 100,000 beds.

The largest sum on this bill for medical cost of the World War is the care and hospitalization of the neuropsychiatric patient. There are now 35,000 such patients receiving total, permament disabilities. The cost per neuropsychiatric case is from $33,000 to $38,000 per man.

How can this huge item of the cost of the war be lessened? By weeding out the men with unstable nervous systems in the first selection.

As the late Dr. Thomas Salmon, formerly Consultant in Neuropsychiatry, A.E.F., said: "It is only the doctor of the Local Draft Board who is able to cull from the selectees the man with the abnormal nervous system." The local doctor may know the registrant or his family and recognize from the registrant's personality or his background that he is nervously unfit for military service.

The man with the perfect physique, but with the unstable nervous system, may go through the war without a scratch, and yet become totally disabled when he "cracks" on going into action. He will be paid total and permanent disability for the rest of his life. Had his mental instability been recognized on his selection, and had he been kept out of a combat unit, he could have served his country and been discharged a healthy individual, to assume his normal place in the community.

The present draft law does not take this lesson sufficiently to heart. There was no specific provision made for psychiatric examinations. However, on

November 7, 1940, the Selective Service issued Medical Circular No. 1, at the insistence of the White Psychiatric Foundation. This circular stressed the importance of referring draftees of questionable personality to a psychiatrist before induction. The average doctor on the Draft Board might have made no attempt whatever to discover the type of individual he was examining. A brief questioning may give the clue for a more exhaustive examination that will save the boy's future happiness and his country's wealth.

The result of a year's experience in the present Selective Draft is alarming. Nearly 50 per cent of the boys have been turned down because they are physically unfit—truly an amazing figure. But of those rejected only 6.3 per cent were refused for psychiatric causes. In the World War only 33 per cent were rejected, and of those only 4.5 per cent on psychiatric grounds.

The selection of Draftees is soon to be taken out of the hands of the Selective Service Boards and turned over to the Army. This change is fraught with great danger. There is grave question whether the Army can eliminate the potential neuropsychiatric case as well as can the physician of his local Draft Board.

In the modern army close order drill has been entirely done away with. The soldier is more than ever an individual. He has not the support and comfort of close companions. He must more or less fight alone. He needs more than ever a stable, well-balanced nervous system. Again, modern armies are to a great extent mechanized. The soldier must have sufficient intelligence to handle sometimes complicated machinery. The responsibility of the modern soldier is much greater than his predecessor—much more depends on him as an individual in a modern army than ever before. Should he fail under fire the consequences are far greater to his command than with the soldier of the last war. He must be physically fit, with a well-balanced nervous system, and, finally, thoroughly trained. It is simple enough to pick out of 130,000,000 people as many physically fit young men as we need, but to be sure they are mentally and nervously sound is a much more difficult problem. Through faulty selection, after thorough and costly training, the soldier may "break" when he first goes into action. He then, immediately, becomes a permanent and total charge on his government.

In an attempt to forestall such a contingency and to evaluate the examinations given by the Selective Service Boards, a restudy of Draftees was recently made by a Board of Psychiatrists. Of those already tentatively accepted, they rejected 29.3 per cent. They estimate that, with proper study, 20 per cent of the Draftees may be rejected purely on neuropsychiatric grounds. High as this figure seems, it is far better that the weaklings be weeded out than that the life and usefulness of the soldier be ruined and his country saddled with greater debt.

Many of the physical causes for rejection are remedial, and there is now being made an attempt to salvage some of the rejectees by surgery or otherwise.

The National Research Council is doing a great work in aiding the

Surgeons-General of the Army and Navy. Through seven main committees, and their numerous subcommittees, they have been studying various problems for the Army and the Navy.

The National Research Council, and the Committee on Medical Preparedness of the American Medical Association, has already accomplished a huge task in classifying every available medical man in the country. The old complaint of a round peg in a square hole, so often heard in the last war, should be eliminated almost entirely.

Through the many committees of the National Research Council and the National Medical Societies, all the best men in the profession are now acting as most valuable consultants to our military services.

It is said, however, that the Surgeon-General does not plan to use consultants in actual combat. No individuals stood out more prominently in the Medical Corps of the A.E.F. than those who did so much to enhance the evacuation and surgical care of the "doughboy." No medical officer of the Regular Army but will attest to the valuable services rendered by the consultants in the A.E.F.

The Surgeon-General recognizes that there is no reserve medical personnel in the nation and that none can be developed in a reasonable time. The brunt of the burden must be borne by the civil population through a reduction of doctors and nurses. These doctors and nurses drawn into the Army must be trained in their extraprofessional responsibilities if they are to discharge their duties to the best interest of the Medical Department.

There are actually 11,526 medical officers in Service, ample for the training program, but far short of what will be needed in actual war.

Preparations for war are well advanced. The training of personnel is well on its way. The equipment for modern war is fast coming off the assembly line. The production of ambulances, surgical instruments, laboratory equipment, and roentgenologic installations, besides equipment peculiar to Field Service, is proceeding apace.

In keeping with the motorization of the Army, the Surgeon-General has developed mobile equipment for surgical hospitals consisting of 14 vehicles, of which seven comprise the operating group.

Bus ambulances capable of carrying 12 litter cases, in addition to the more mobile front line ambulances, are being prepared. Some of the latter will have light armor protection, carry medical personnel and supplies, and can function as mobile aid stations with facilities to transport casualties.

The status of the airplane for rapid evacuation is being studied. Army troop transport planes are equipped with devices for securely holding litters, and can be, almost instantly, converted into airplane ambulances. But these large planes require landing fields of fair size, so that their effectiveness may be limited. The use of the autogyro, that can carry two or three litter cases and needs no landing field, is being investigated.

Medical Department personnel, commissioned and enlisted, are being trained for service with parachute troops. Their equipment, consisting of litters, splints, dressings, and drugs, have been prepared and packed into

standard containers used by the combat unit for dropping its ammunition, food, *etc.*

Hospital trains are being equipped with cars with facilities for rendering medical and surgical care by a completely furnished operating set-up. In addition, each train will have four hospital ward-cars, with beds for 128 patients as well as accommodations for officers and enlisted men.

The program of preparation for National Defense by the Medical Department of the Army is well advanced. The personnel and the equipment have been undergoing severe tests on maneuvers here in the Carolinas.

The experience gained in these maneuvers seems to stress the advantage of younger men in the Army. It is already apparent that many of our own Line officers have passed the age when they are best adapted to the strenuous life of an army campaign. This is undoubtedly true of the Medical Corps as well. Though age, experience and sound judgment will be of great value in the council room, youth must be given the leading rôle in actual combat. In our particular field—surgery—this is of paramount importance. Our young residents, our recent graduates, with adequate postgraduate training, and the junior members of our hospitals and university staffs, will form the surgical teams of this man's Army.

The supply of competent medical officers is now insufficient for our present needs. Many more medical officers will be required. The Surgeon-General has already asked the medical schools to encourage enlistment of their students as members of the Medical Administrative Corps on inactive duty—to be changed over to the Medical Corps proper, when they have graduated and had at least one intern year.

Autocracy is in the saddle again. Again Democracy reels under the all too efficient might of the conqueror. Again we see man's hard-won freedom threatened.

We, in the United States, are guilty of, at least, a share in the failure of the First World War. We must see to it that failure does not occur again.

It was hoped that the Axis Powers could be crushed by the embattled democracies of Europe, with only our material aid. But it is now certain that not only weapons but man power will be needed. Our every effort should be concentrated on seeing that our Army and Navy are well trained and well equipped.

We of the medical profession must see that the armed forces are selected from the cream of our youth.

Again we must see that the fighting man's health is carefully protected.

Again we must see that his medical care is of the best, should he fall ill or should he be wounded.

Every selfish interest in the nation must be subordinated to the great task that lies ahead. Labor must be curbed and forced to assume its true responsibility. Nothing must be allowed to interfere or halt our progress.

The enormous resources of this great nation, her genius for organization and mass production, and last, but far from least, her manhood, can and will win the war.

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OXYCEPHALY*

JOSEPH E. J. KING, M.D.
NEW YORK, N. Y.

OXYCEPHALY and its related disorders (acrocephaly, dolichocephaly, scaphocephaly, "tower-skull," Turmschädel, Schädelmissbildung, *etc.*) are being considered in this paper. In all of these conditions the sutures may be closed at an early period in life. This leads to malformation of the skull. It may be pointed like a tower, sway-backed, or wedge-shaped. The suture lines close tightly and are obliterated previous to the closure of the anterior fontanelle. This process—craniostosis—prevents the proper development of skull and brain. The brain continues to exert marked intracranial pressure in all directions and the skull gives way before the pressure at the point of least resistance, usually most marked in the region of the anterior fontanelle. This fontanelle is the last part of the suture line to close and the bone-margin at this site is the thinnest and least resistant. With the oncoming progressive increase in intracranial pressure, the bony margins are pushed upward, and further ossification takes place about the area of the fontanelle, until, finally, complete ossification occurs. The result is a distorted, misshapen skull, with the most prominent and bulging portion at the site of the fontanelle. Thus, "oxy"—pointed, "cephalus"—head. The head may be elongated and scaphoid with the most prominent protuberance at the same site.

It is not uncommon to see persons with queerly shaped heads who have normal physical and mental capacities, due to arrest of the condition. On the other hand, oxycephalic individuals may never attain adulthood. Why? The simple answer is that premature closure of the suture lines prevents the intracranial space from keeping pace with the actual growth of the brain and its coverings. In other words, the brain outgrows its case and vital functions cease. The brain is not pathologically small, but the intracranial space is. Therefore, the growth and development of the brain is restrained or held back. (Distinction between this condition and that of the microcephalic or mongoloid idiot must be made.)

It is well known that growth of the brain takes place at a rapid rate in the early years. When the brain continues to grow in such cramped quarters, certain symptoms, signs and characteristics make their appearance: (1) Headaches, which may occur at such an early age that they are not recognized; (2) irritability and mental dulness; (3) characteristic convolutional markings and thinning of the skull, with absent or hardly distinguishable suture line sites; (4) thinning of the dura; (5) unusual and abnormal irregularities of the skull involving most frequently and prominently the site of the anterior fontanelle; (6) tremendous increase in intracranial pressure as shown by measurement of the intraventricular pressure and extreme diminution in the

* Read before the Southern Surgical Association, Pinehurst, N. C., December 9–11, 1941.

size of the ventricles (ventriculograms); (7) bilateral papilledema, followed by atrophy, resulting in failing of vision and blindness; (8) marked bilateral exophthalmos, which may be so extreme and prolonged that loss of the eyes may ensue; and (9) generalized convulsions. If the condition does not become arrested, it progresses gradually, and death ensues.

Although the cranium may be distorted into various forms, some special roentgenologic findings are always present and show great similarity. One of the most distinctive features is the generalized convolutional markings of the bones forming the cranial vault, giving a wavy, billowy appearance like fluffy clouds. This effect is more marked in the lateral view where all bones forming the cranial cavity (with exception of the base) show similar, if not identical, markings. The floors of the middle and posterior fossae are depressed with corresponding depression of the petrous pyramid and ears, and depression, relative lengthening, and narrowing of the sella turcica. The frontal, sphenoid and maxillary sinuses are small. The orbits are blunted and shallow, thus decreasing the orbital capacity. The lower jaw is prognathous and protrudes prominently due to downward displacement of the mandibular fossa.

All of these findings result from the slow, progressive and marked increase of intracranial pressure against slowly retreating, but nonelastic walls of the cranial cavity. In passing, it might be noted that vision fails earlier, and to a greater degree than hearing, because the bony confines of the orbit are more vulnerable than the petrous. In 1936, the author was confronted with this problem. In search of the literature, an operative procedure which would provide adequate relief could *not* be found. In an endeavor to find such a solution, recurring thoughts continually led one back to the basic fact —the intracranial space was too small to allow proper growth and expansion of the brain. The question then arose: How can the cranial cavity be enlarged sufficiently and symmetrically? The problem was solved by the operation which is herewith described. It was conceived and performed first on November 10, 1936, and was described in a preliminary report of the case in November, 1937.

OPERATIVE PROCEDURE

The procedure may be carried out in two stages, as in the first case operated, but the one-stage operation is preferred, provided circumstances permit. With the patient in the prone position, head resting on a proper support, the drapes are sutured to the scalp so as to expose the head from the supraorbital regions to the external occipital protuberance, and from the conchotemporal sulcus of the one side to that of the other side. A straight, midline incision is made from the hair-line anteriorly backward almost to the external occipital protuberance (Fig. 1 A). If deemed necessary, the posterior extremity of the incision can be extended laterally in an oblique direction, forming an inverted Y. The incision extends through all soft parts to the outer table. Bleeding from the scalp is prevented by application of skin clips. The pericranium is readily stripped from the outer table as far as the superior

temporal lines. In this area the pericranium is more adherent, and greater care must be used in freeing it to prevent tearing and fraying of the pericranium, accompanied by bleeding. The entire outer table is thus exposed from supra-orbital regions to the occiput, and from the low temporal region

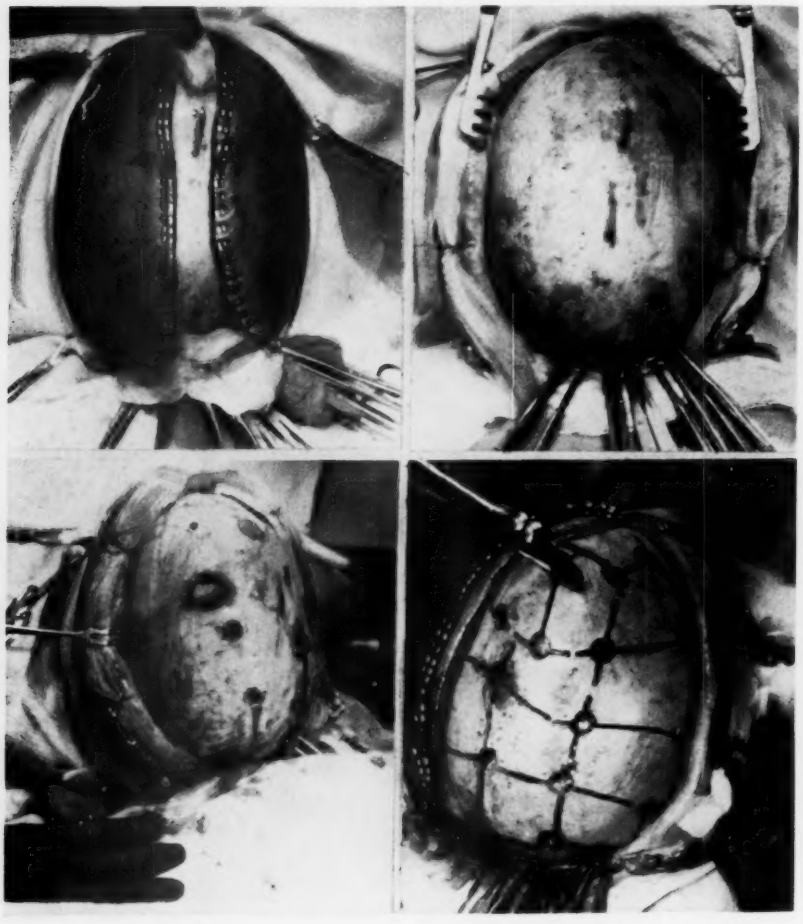


FIG. 1.—Various stages of the operation: (A) Midline straight incision, with inverted Y extension posteriorly. Skin clips used to control bleeding from scalp. (B) Soft parts, including pericranium, have been reflected exposing outer table of cranium. (C) Circumferential and other bur-holes have been made, bleeding from some being controlled by pledgets of cotton. (D) Skull segments cut with deVilbiss bone forceps. Segments should be smaller in the area of greatest prominence.

of one side to that of the other (Fig. 1 B). The skull may be so thin in areas that it has a bluish-gray tint. Bur-holes are made in a circumferential manner, about one and one-half to two inches apart, and similar bur-holes are made throughout the circumscribed area (Fig. 1 C). The frontal sinuses offer no problem since they are either absent or quite small. The openings should be placed closer together over and near the most prominent bulging part of

the skull. The bur-holes are then connected with a deVilbiss bone-cutting forceps (Fig. 1 D), or an electrically driven fraise.

When the first groove is cut between two openings, it will be observed that the dura protrudes through the groove similar to the manner in which a towel will "buckle" when two books are placed on it near each other and pushed together. This fact proves redundancy of the dura and sufficiency of the intradural space as compared with the paucity of the intracranial capacity.

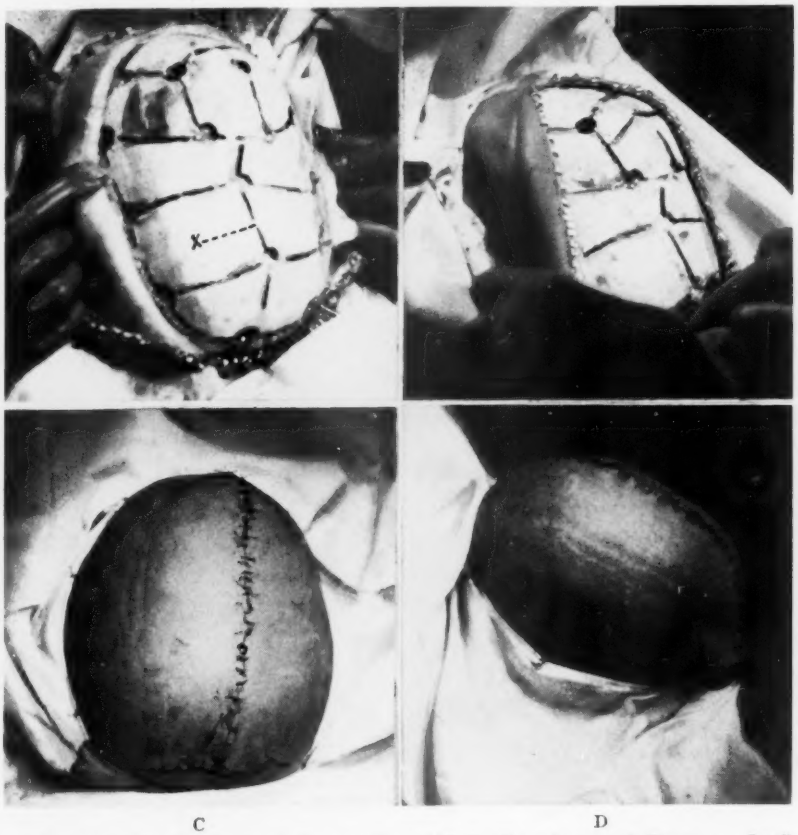


FIG. 2.—Concluding steps of the operation: (A) Semilateral view of Figure 1. Small "isthmi" of bone (X) remain while other segments are fashioned, and cut through just before closure. (B) Shows separation and elevation of skull segments still attached to the dura. (C and D) Incision closed without drainage.

The dura is quite thin and glistening. When the bone is cut through on three sides leaving the bone flap attached on one side or end, it will be observed that the free end of the bone flap rises and falls like the end of a springboard, with pulsation of the brain. From these two observations it is easy to believe that the brain will expand and reduce the intracranial pressure after all the bur-holes have been connected. This proves to be a fact.

With regard to the shape and size of the skull-segments, it can be said that they should be neither too large nor too small. If they are too large, proper

symmetrical shaping of the skull will not be accomplished, and if they are made too small, too much time will be consumed. Some of the skull-segments will be square, some rectangular, others triangular, trapezoid, *etc.* The skull is thin and cuts readily. In the temporal region the skull may be very thin, like paper, or may even be absent in areas. In the low temporal region it is well to remove the bone entirely with rongeurs, leaving a defect measuring about two inches in the horizontal, and one and one-half inches in the vertical directions, unless the skull is sufficiently large in these areas.

Caution should be employed in two particulars: (1) The dura should *not* be opened, to avoid loss of cerebrospinal fluid. (2) It is well to leave the skull fragments connected by small "isthmi" of bone (the last bite of the deVilbiss forceps) until all of the segments have been fashioned (Fig. 2 A). Otherwise, the skull fragments, being insecurely attached to the dura, may slip to the floor and cause embarrassment. The grooves can be cut across the longitudinal sinus with readiness, but, in so doing, "blue" areas, indicating more prominent and embedded portions of the sinus, should be avoided. When all skull segments have been fashioned and cut as desired, the remaining small intervals of bone between adjacent pieces are divided. The intervals, or "grooves," between the various segments increase two or three times in width. The bulging at the site of the anterior fontanelle will disappear completely, provided the skull fragments are sufficiently small over this area. Otherwise the deformity will partially remain.

Bleeding or oozing will be constant from both skull and dura, but the total amount of blood lost is not significant or distressing. The use of bone wax is not advised. It is not necessary, and is a foreign body.

The operation is completed except for closure of the incision (Fig. 2 B). This is accomplished by the use of two layers of interrupted silk sutures, one for the pericranium and galea and one for the scalp—without drainage—(Fig. 2 C and D). A copious head dressing, including the lower jaw and both ears, is applied without pressure. A light plaster of paris skull cap is placed over the dressing for protection. A small transfusion should be administered.

CASE REPORTS

Cases 1 and 2, operated upon by the author, have been reported, but a résumé of each case will be given, with additional data. Cases 3 and 4 were operated upon by Dr. Barnes Woodhall of Duke University. He has kindly permitted the author to include them in this paper. Although a brief report of these two cases has been made, the completeness of the clinical records justifies a more detailed account.

Case 1.—E. C., white, male, age 8, was admitted to the Hospital for the Ruptured and Crippled (H23-467), August 10, 1936, for correction of a malunited fracture of right femur. In November, 1935, he had been run over by a truck and sustained a fracture of the right femur. He had been operated upon five times, including plating, without success.

He was fairly well-developed, but rather small for his age. Aside from the deformity of the right femur, the outstanding feature was marked bilateral exophthalmos, with external squint. No ophthalmoplegia (Fig. 4 C).

Examination of the right fundus showed marked pallor of the disk. On the left the disk was slightly pink. No papilledema. Pupils reacted to light and accommodation. Mentality fairly good, but he had a somewhat dull, apathetic countenance. General neurologic examination was negative.

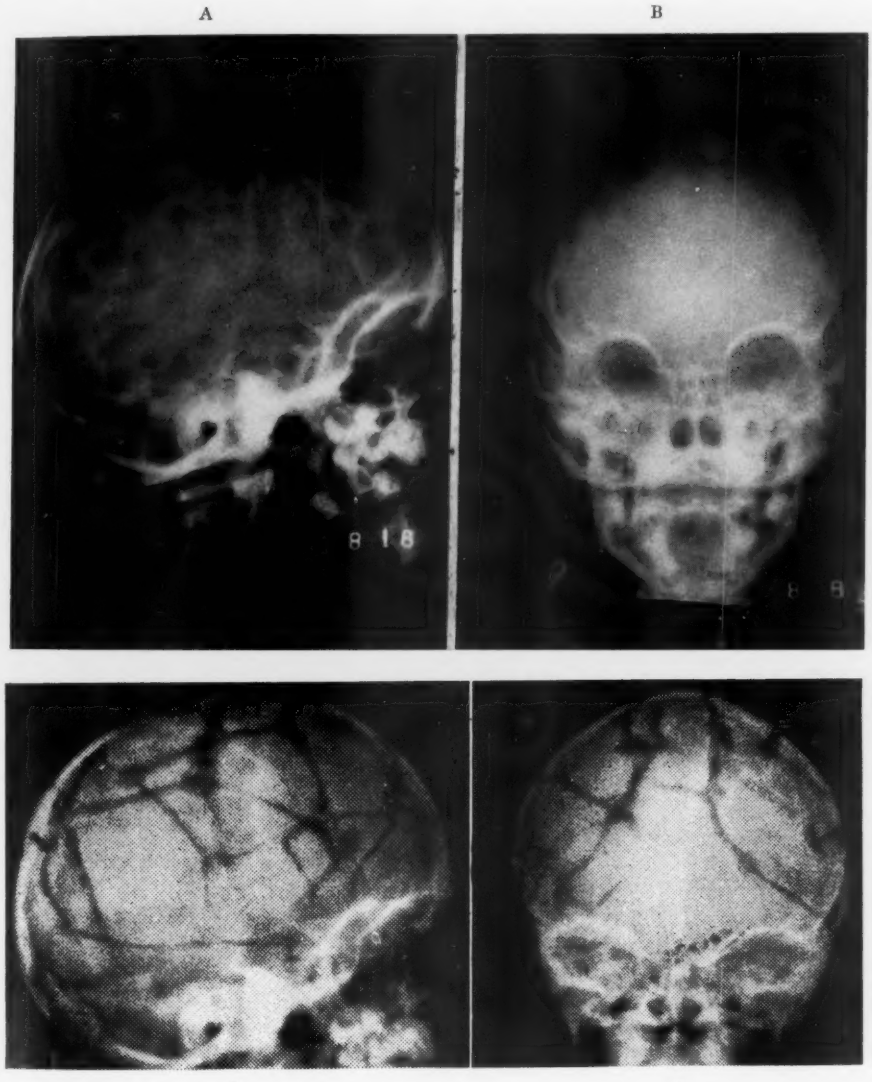


FIG. 3.—Case 1.—E. C.: (A) Preoperative lateral roentgenogram of skull showing convolutional markings, deep, narrow sella turcica, and other typical findings. (B) Preoperative A.P. view of skull, narrow and pointed above. (C and D) Roentgenograms made February 3, 1937, one week following second stage of the operation. Compare with A and B

Lumbar puncture showed increased pressure to 400 Mm. of water, reduced to 250 Mm. after removal of 30 cc. of cerebrospinal fluid.

Roentgenograms revealed typical changes in the skull (Fig. 3 A and B). Ventriculograms showed small, generally compressed ventricles. Intraventricular pressure was

greatly increased. Vision was poor, unable to read, and could barely recognize doctors and nurses standing at the foot of his bed.

Upon the request of Dr. Philip D. Wilson to operate upon the boy, the literature was searched for a method of procedure. None seemed to offer much hope for a good result. The operation herewith described was conceived and carried out in two stages. The first stage was performed November 10, 1936, on the right side. Immediately following the first operation there was marked recession of the eyeballs, more on the right side than the left, with improvement in vision. Pronounced symmetrical increase in the size of the cranium on the right side was accompanied by widening of the grooves between skull fragments.

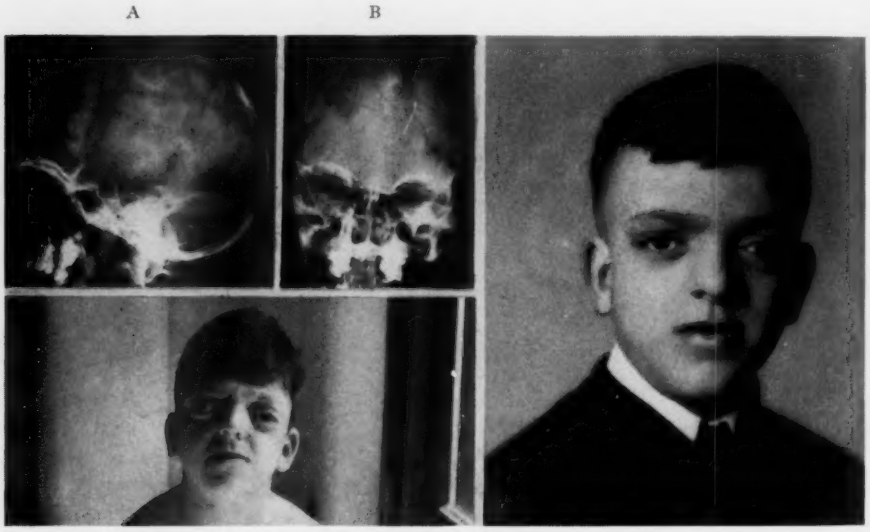


FIG. 4.—Case 1.—E. C.: (A and B) Roentgenograms made August, 1941, about four and one-half years after those shown in Figure 3 C and D, with which compare. (C) Photograph of patient before operation. (D) Photograph of patient about four years after second stage of operation.

Second Stage: A similar procedure was carried out on the left side, January 26, 1937, with corresponding increase in size of cranium on that side.

Roentgenograms, February 3, 1937 (Fig. 3 C and D), showed symmetrical enlargement of the cranium, as desired. Softness, or doughiness, of both sides, similar to that of a flaxseed poultice, was present for about two and one-half weeks, followed by slow, gradual stiffening of the cranial vault, until the cranium showed firmness of an ordinary skull (about three months following each stage).

Recovery from both procedures was uneventful. Vision improved. Successful reduction and correction of malunited fracture of femur was undertaken by Doctor Thompson, December 2, 1936, almost two months following the first stage. The patient was discharged, March 17, 1937, and returned to Halifax, Nova Scotia. At this time the fundi and vision were practically normal.

Letters received from him and his grandmother since his discharge informed us of his return to school and keeping up with his studies. He was skating and indulging in activities enjoyed by other boys. Roentgenograms of the skull were made from time-to-time. Shape and size of skull remained normal. No evidence of return of oxycephalic condition.

He visited New York in August, 1941. Roentgenograms, made at that time, revealed a normal shaped head on both anteroposterior and lateral views (Fig. 4 A and B). The

relative depression of the middle fossa was not so marked. The shape of the sella had completely changed. In the original film, made in 1936, the sella turcica was not only depressed, but was deep and narrow in the anteroposterior direction. In the latest films the sella was normal in contour, being much wider in an anteroposterior direction than in the vertical direction—quite the opposite to the condition seen on the original films. The sphenoid was well developed. New bone had filled the groove lines; also, in both temporal regions from which it had been removed. The upper jaw had developed least of all, and the lower jaw was still prognathous.

Mentally the boy appeared normal. He accompanied the author to a motion picture theater, quickly appreciated all the jokes, and readily perceived the details of the picture without any difficulty at a distance of about 200 feet. He gave all appearances of being a normal individual (Fig. 4 D).

A

B

FIG. 5.—Case 2.—I. H.: (A and B) Photographs made before operation, showing pointed, deformed skull, mild exophthalmos, and protruding lower jaw.

Case 2.—I. H., Negro, male, age 5, was admitted to Lawrence Hospital (No. 42637), Bronxville, N. Y., October 17, 1940. History of normal birth; 12 children, 7 living. A brother, age 6, showed elongated flattened skull, with prominence in the region of the anterior fontanelle (dolichocephaly); otherwise normal. No other history of malformation of skull in family.

Examination revealed a rather bright, intelligent child for his age. General and neurologic examinations were negative. Lumbar puncture, ventriculograms, encephalograms and electroencephalograms were not considered necessary. There was slight bulging of the eyes; constituting a mild exophthalmus. Intrinsic and extrinsic eye muscles were normal, and eye grounds were normal.

Head was typical "tower-skull," narrow and pointed, more pronounced in the frontoparietal region (site of closed anterior fontanelle). There was apical bulging, elevated about one and one-half inches or more above the surrounding narrow skull (like a haystack) (Fig. 5 A and B).

Roentgenograms showed a peculiarly shaped, pointed skull, with convolutional markings and other typical changes (Fig. 6 A and B).

In order to prevent mental and visual disturbances which were present in Case 1,

the proposed operation was carried out, October 22, 1940, but in one stage (Figs. 1 and 2). During the procedure the same phenomena, *i.e.*, bulging dura through grooves between skull fragments, pulsation of bone flap, expansion of brain with separation of segments, restoration of contour of skull, etc., were observed. When the operation was completed the proper shape of the skull was restored and eyes were less prominent.

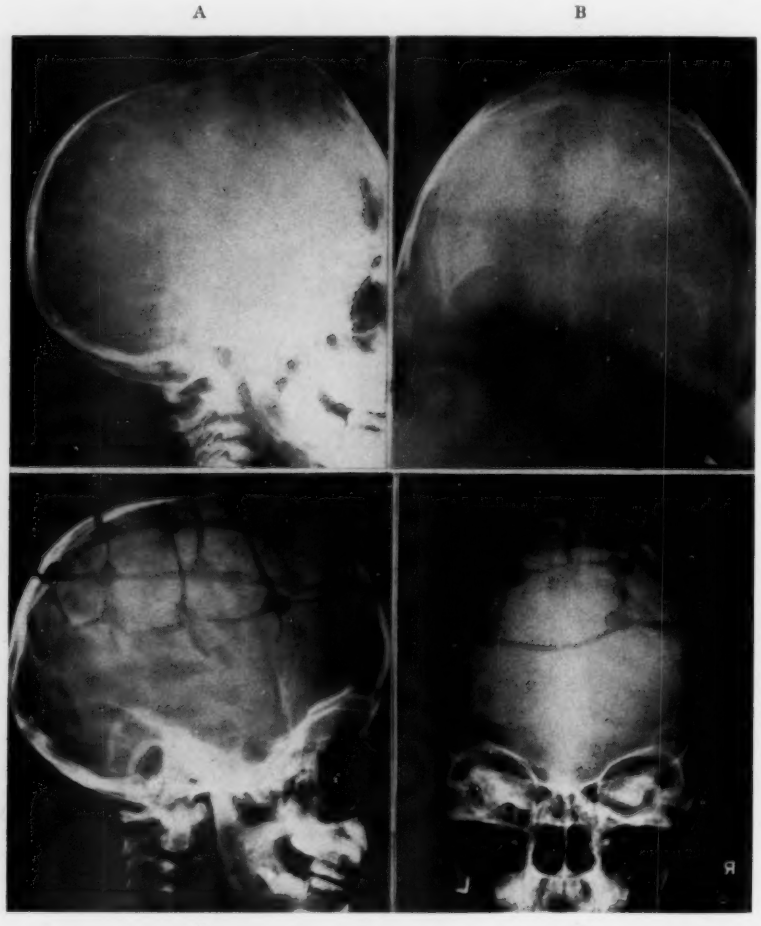


FIG. 6.—Case 2.—I. H.: (A and B) Roentgenograms made before operation. Note marked deformity and bulging at site of anterior fontanelle. (C and D) Roentgenograms made ten days postoperative, showing widening of grooves between skull segments and correction of deformity.

Result.—The patient had an uneventful recovery. Roentgenograms, ten days after operation, showed approximately 17 bur-holes in frontal, parietal and temporal regions, with bone cut between holes, leaving a checker-board appearance in the upper half of the cranial vault. The deformity of the upper and anterior portion of the cranial vault, apparent on the original films, had completely disappeared (Fig. 6 C and D). There was evidence of solidification of skull as in Case 1. The patient was discharged on the 28th postoperative day, November 19, 1940, and has remained well.

More recent films, made in November, 1941, reveal a skull normal in contour, and ossification of the grooves between skull fragments. The midline had been crossed at

seven points, and the union of these segments is firm. Convolutional markings in the segments have disappeared, while some evidence of the markings persists in the unsegmented portion of the skull.

Case 3.—M. McK. (patient of Dr. Barnes Woodhall), colored, female, age 4, was

A B C

FIG 7.—Case 3.—M. McK. (Operation by Dr. Barnes Woodhall): (A and B) Photographs before operation August 28, 1939 showing marked deformity of head and bilateral exophthalmos. (C) Photographs after second stage of operation. Note almost perfect contour of head and diminution of exophthalmos.

A B

FIG. 8.—Case 3.—M. McK.: (A) Preoperative roentgenogram showing characteristic features. (B) Postoperative roentgenogram made following second stage of operation. Note widening of grooves and correction of deformity.

admitted to Duke Hospital, Durham, N. C. (No. A–22502), in August, 1939. Her chief complaints were headaches and eye trouble for two years.

Family history was noncontributory. Past history was negative except for chronic head colds and pneumonia at three years of age.

Present Illness.—The mother noted that at birth the patient's head was somewhat distorted. She got along well until two years before admission, when she began to complain of frequent frontal headaches. The child would wake up at night and complain of

severe pain for a few minutes and then fall asleep again. Later she began to complain of headache throughout the day. At the onset of the headaches the mother noticed that the eyes began to protrude, and that they continued to become more prominent until admission. She continued to have severe frontal headache, and, recently, the mother noticed that the child walked with a staggering gait and with a broad base. She did not vomit with the headaches. The mother stated that the child had increasing disturbance of vision.

Physical Examination.—Temperature 36.8° F.; pulse 92; respirations 20; blood pressure 135/84. The patient was a well-nourished but poorly developed colored female, age 4, who was very cooperative, and did not appear to be acutely ill. The examination was entirely negative except for involvement of the head. Her head was distorted (Fig. 7 A and B), approximately normal in diameter in the temporal regions, but over the frontoparietal region the skull came up to a point at the site of the anterior fontanelle and was completely ossified. The anterior and posterior fontanelles were closed. There was marked bilateral exophthalmos. The nose was saddle-shaped, and there was bilateral obstruction to breathing. The hard palate is excessively high, and the lower jaw projects forward considerably.

Neurologic Examination.—The patient was mentally clear and very cooperative. All of the cranial nerves were intact. There was some distortion of the optic disks, in that they were oblong in shape. The margins were well outlined. There was no evidence of papilledema. Both disks were slightly pale.

No localized muscular weakness or atrophy was noted. All reflexes were present, equal, and moderately active throughout, except for ankle jerks, which were sluggish. There was no Babinski. No changes were noted to light touch, pain or vibratory sense. Position sense and coordination of movements appeared to be good.

Laboratory Data.—Examination of the blood revealed the following: Hemoglobin 73%; R.B.C. 3,340,000; W.B.C. 13,450; Mono. o. L.L. 5; S.L. 58%. Uranalysis revealed a slight trace of albumin and an occasional white cell. There were no red cells or casts. Benzidine was negative. Wassermann was negative.

Roentgenograms of skull showed a dolichocephalic skull, with unusual prominence of the frontal bone. There was marked increase of intracranial pressure with typical convolutional markings. All the suture lines were entirely closed (Fig. 8 A).

Impression: Craniostenosis. Suggested treatment: Surgical decompression.

On August 29, 1939, a right subtemporal decompression was performed, under bactericidal radiation and avertin-ether anesthesia (Doctor Woodhall). A rather large opening in the skull was made and the dura was opened. Her convalescence from this procedure was quite uneventful, although there was a continual deposition of fluid beneath the subtemporal decompression incision, which had to be aspirated on several occasions.

About this time, the operator became cognizant of the operation for oxycephaly proposed and carried out by the author, and felt that it should be applied in this case. The reason for doing so was the obviously increased intracranial pressure and because of his experience in some ten or 12 previous cases, in which bitemporal decompression had not been particularly effectual in controlling the process. Accordingly, on September 8, 1939, the first stage of the operation proposed by the author was carried out on the right side, the procedure being designated as the "morcellation" operation.

Operation was performed for dolichocephaly (oxycephaly) right side. Dural transplant was performed. Under bactericidal radiation, and avertin-ether anesthesia (by Dr. Barnes Woodhall): The effusion under the scalp at the site of the decompression had returned and it was reaspirated at the beginning of the procedure. The entire right half of the scalp was prepared in the usual manner and a sweeping incision made to include the entire right side of the scalp with the mesial border of the incision on the midline. The large flap was turned down without much difficulty, exposing the outer table of the skull on the right side and the site of decompression. The brain was protruding markedly through the subtemporal decompression, and it was quite obvious to the operator that he was correct in assuming that something more had to be undertaken in this particular instance. At this time, a section of the pericranium in the occipital region was dissected

out and sutured in place over the exposed brain in the subtemporal region so that no further effusion of subarachnoid fluid could develop. The entire right side of the skull was then encircled by perforator openings about 4 cm. apart, and an inner circle also was made so that the entire right side of the skull could be sectioned in a definite mosaic. The dura was dissected free from the bone, and a mosaic pattern was carried out with the deVilbiss rongeurs. It was not attended with much bleeding. Across the midline, grooves were cut with the deVilbiss forceps in three areas over 3 cm. beyond the midline into the left side, where they will be joined within about three months with the mosaic on the left side. The scalp flap was then sutured in place with interrupted fine black silk sutures and the skin was closed with continuous silk. (Before the incision was closed a sketch and natural and color photographs were made.) It was necessary to give the child some glucose and blood during the procedure.

Her convalescence from this operative procedure was quite uneventful, and on September 18—ten days postoperative—a head encasement was applied. She was discharged, September 24, 1939, greatly improved, having no headaches, and having definite recession of the exophthalmos, particularly on the right side.

On October 23, 1939, roentgenograms showed still further separation of the trephine areas, the bone segments in the right parietal region seemingly almost completely separated.

The child was readmitted to Duke Hospital (Hist. No. 1 C–21946) for the second stage of the operative procedure, at which time she stated that she had continued to be free from headaches and eye disturbances. There was a large, soft bulging of the head in the right temporoparietal region at the site of the original decompression, measuring approximately 12 cm. across. On palpation, it was very soft, with no underlying bone palpable except for two small detached fragments anteriorly. In addition to the soft swelling, however, the bony portion of the right side of the skull was definitely fuller, or better filled and rounded out than on the left, where the absence of fulness was quite apparent pathologically. There was only slight, if any, abnormal tension in the bulging area. There was a pronounced exophthalmos on the left and a moderate endophthalmos on the right.

Neurologic examination revealed no papilledema and all cranial nerves were intact. There were no motor or sensory changes and the reflexes were physiologically and bilaterally equal. Head measurements were as follows: Top of ear to top of ear 27 cm. Inion to nasion 35 cm. Greatest circumference of head 51.5 cm.

Exophthalmometer reading with the instrument set at 101 O.D. 23; O.S. 25. Ophthalmoscopic examination through undilated pupils revealed the elliptical disks, which indicate a moderately high degree of astigmatism. Retinal vessels were normal. There was no congestion of retinal veins. The peripheral fundi were normal. The maculae stood out rather distinctly. Vision with the illiterate chart was approximately 20/40 in each eye.

Because of an acute rhinopharyngitis the second stage of the operation was delayed until January 19, 1940, when all symptoms had disappeared.

The second stage of the operation was undertaken January 19, 1940. It was carried out in a similar manner to that of the right, except for the fact that there was no decompression site to be dealt with; also, the grooves could not be carried across the midline with the de Vilbiss forceps because of marked venous bleeding which developed in this region and for fear of damage to the longitudinal sinus. Nevertheless, there was noticeable separation of the bony incisions and actual distention of the hemisphere on the left side. The incision was closed as at the first stage.

Postoperative course was uneventful. On January 30, 11 days postoperative, a head encasement was applied, and the patient was discharged (Fig. 7 C). On April 10, 1940, she returned for observation. The mother stated that the child had become really a new child, had no headache, and appeared to have no visual disturbance. The head measurements showed the greatest circumference 53 cm.; top of ear to top of ear 28 cm.; and inion to nasion 37 cm. Exophthalmometer readings were 28 bilaterally, set at 113.

The patient returned on May 27, 1941. She had had an uneventful course since the last operation. She had no headaches, no convulsions, normal vision, normal speech, and normal mentality. The mother stated that the child had acted very much like a normal child should. Her head measurements showed the greatest circumference of 55.5 cm. as compared with the preoperative measurement of 51.5 cm.

Examination of roentgenographic films of the skull in comparison with those of October 23, 1939 (Fig. 8 A and B) showed practically complete union of the bone fragments except in the frontoparietal regions and the occipital region, and in these regions some bony union appeared to be taking place. There was also some disappearance of the convolutional atrophy previously noted. Some general filling-out of the cranial vault had taken place, and it was more normal in contour than on previous films. It was noted that the present appearance, all-in-all, was a decided improvement over that of 1939. This opinion was substantiated by the operator's observations and the observations of the nurses on the pediatric ward, who had followed the child for two years. Peripheral visual fields, taken at the time, showed normal findings.

On account of living near the hospital she was to be followed during later years.

Case 4.—T. C. (patient of Dr. Barnes Woodhall), white, female, age 14, was admitted to Duke Hospital, Durham, N. C. (Hist. No. A–41861), June 5, 1940. Chief complaint: Convulsions, ten months' duration.

Family and past history were noncontributory. Present Illness: The patient was born with a peculiarly shaped head and protruding eyes. She had always been nearsighted, and was somewhat small for her age. Other than this the child behaved well until ten months prior to admission when she began to have convulsions characterized by cyanosis, unconsciousness, urinary incontinence and drawing of hands and legs. These attacks occurred five or six times a night.

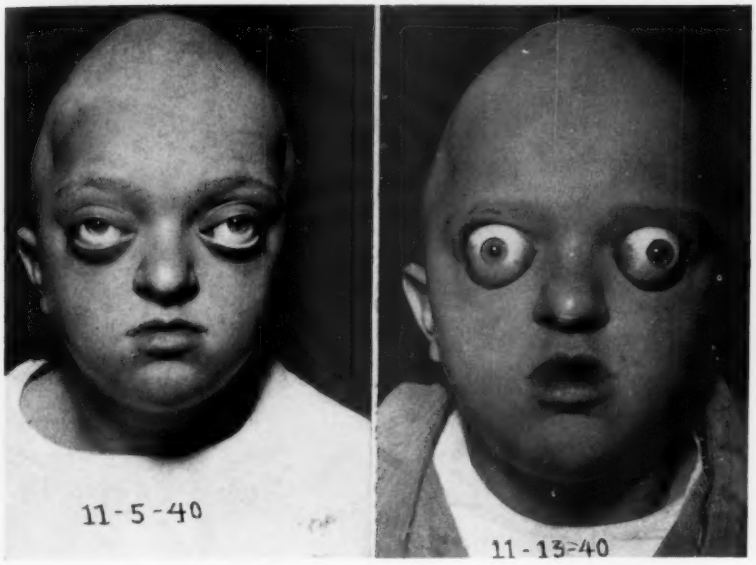
Physical examination was negative except for head. There was a marked bilateral exophthalmos. The upper lip was somewhat undershot and the nose had a definite hook to it. All the features were characteristic of oxycephaly. The head itself was small in all diameters, somewhat flattened posteriorly, and of striking interest was the presence of a smooth bulge in the region of the anterior fontanelle. This bulge measured about 4 or 5 cm. in diameter. The optic disks were hazy and were interpreted as being indicative of mild increase of intracranial pressure. Vision was 20/200 in the right eye and 20/400 in the left eye. There was mild generalized constriction of both visual fields.

Stereoscopic roentgenograms of the skull showed oxycephaly with marked increase in intracranial pressure, as evidenced by the convolutional markings with none of the suture lines being present (Fig. 10 A). The sella was not enlarged but was unusually deep. (This corresponds with the findings in other cases of oxycephaly.) The narrowing and deepening of the sella were interpreted as also being due to pressure.

A lumbar puncture was performed and encephalograms made. The initial manometric reading was 220 Mm. of water. The encephalograms showed typical findings, *i.e.*, marked diminution in the size of the ventricular system, without loss of ventricular symmetry. Spinal fluid showed total proteins of 18 mg. %. Blood Wassermann and Kahn reactions negative, as was the spinal fluid Wassermann. An electroencephalogram showed the presence of *delta* waves over the entire cortex, indicating diffusely increased intracranial pressure. The patient was discharged, and preparations were made for operation.

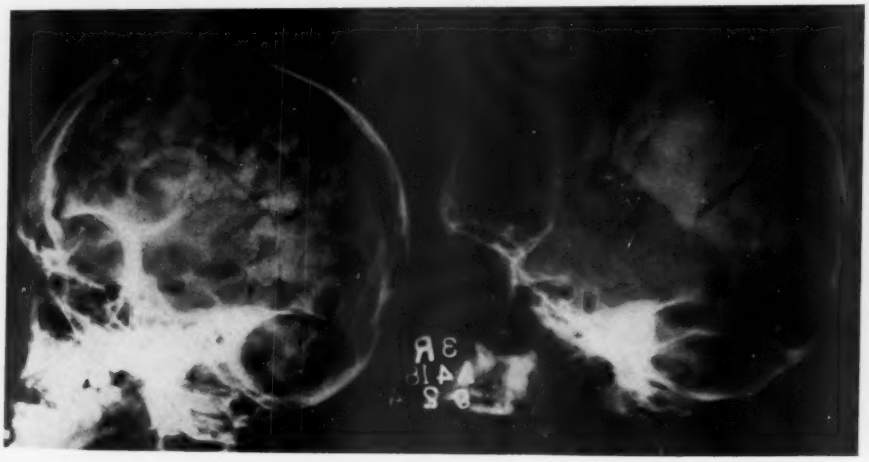
She was readmitted to Duke Hospital, November 4, 1940. Endocrine examination showed oxycephaly, marked bilateral exophthalmos (Fig. 9 A), retarded statural growth, partially retarded sexual maturation, headaches and convulsions. The conclusion was secondary hypopituitarism due to increased intracranial pressure incident to oxycephaly. Intelligence tests revealed the patient to be a low-grade moron. Prognosis for future development was not good.

Head measurements showed the circumference 49.5 cm.; diameter from inion to glabella 15 cm.; lateral diameter from one superior conchotemporal fold to the other



A B

FIG. 9.—Case 4.—T. C. (Operation by Dr. Barnes Woodhall): (A and B) Preoperative photographs showing extreme exophthalmos and dull countenance.



A B

FIG. 10.—Case 4.—T. C.: (A) Preoperative roentgenogram after air injection. Note very small compressed ventricular system. (B) Roentgenogram made about 11 days after the second stage of the operation. Note separation of skull fragments; the new growth of bone in the skull defect in the right subtemporal region; and correction of deformity.

12.5 cm. Exophthalmometer readings, with the instrument set at 112, were 26 Mm. in both eyes, visual fields considerably constricted. Visual studies showed 20/400 in the right eye and 10/400 in the left eye. Both fields were considerably more constricted than at the time of the last admission, almost down to the point of macula vision in the left eye. Audiograms disclosed normal hearing in both ears. An electroencephalogram showed slow enlarged and misformed waves abundant over all regions during the resting state, being most marked over the right occipital region.

On November 13, a photograph was made showing extreme exophthalmos with protrusion of both eyeballs beyond both lids; in fact, the under surface of each eyeball was in contact with the skin overlying the lower rim of the orbit (Fig. 9 B).

On this date operation was carried out on the right side by Doctor Woodhall, in the usual manner. Bone was removed from the right subtemporal region, but the dura was not opened. The dura expanded markedly through the bony defect. Morcellation was carried out. The resulting expansion was more marked than observed in Case 3. Immediately following completion of the dressing and application of the bandage, it was quite remarkable to see the diminution of the exophthalmos involving the right eye, whereas the left eye remained protuberant.

An electro-encephalogram made December 13, one month postoperative, showed the amplitude of the waves within normal limits throughout the entire record, a marked improvement—normalization—of the electroactivity compared with the record of November 5.

At discharge, December 14, direct vision was 20/200 in the right eye and 20/400 in the left. Circumference of head in horizontal plane was 49.5 cm. preoperative, and 50.5 postoperative; in the saggital plane 28 cm. preoperative, and 28 cm. postoperative; in the coronal plane 27 cm. preoperative, and 28 cm. postoperative. With the ophthalmometer set at 112, preoperatively, both eyes show 26 Mm. Postoperatively, the ophthalmometer set at 108 showed 24 Mm. both eyes. The patient was to return at three-month intervals for observation.

Patient was readmitted to Duke Hospital, August 24, 1941, for the second stage of the operation. It was noted that the patient had not had any convulsions since the first operation, and headaches have been very mild.

Plain roentgenograms of the skull showed definite evidence of healing, particularly over the transverse resection areas and in the subtemporal area. Where the bone had been completely removed, almost one-third was covered by new bone. This was perfectly obvious upon palpation of the defect.

The second stage of the operation was carried out on the left side, by Doctor Woodhall, under bactericidal radiation. Avertin-ether anesthesia was used. The bone was completely removed in the low temporal squama as was done on the right side. Marked increased intracranial pressure was evident with elevation and separation of the individual skull segments. The scalp incision was closed. The patient's condition was excellent throughout the operation, followed by uneventful healing of the wound (Fig. 11 A and B).

Postoperative electro-encephalography showed irregular waves of not enlarged amplitude and of continuously changing frequency over all regions. Pathologic forms absent. No *alpha* rhythm was present. Overventilation, in contrast to the former examination, has no influence upon the pattern. No special irregularities in the right parieto-occipital region were evident. The record was regarded as within the range of normal.

Head measurements following operation: Circumference 53 cm., nasion to inion 33 cm. Postoperative roentgenograms were made (Fig. 10 B).

Psychometric examination was carried out at this time, and indicated an improvement in the patient's mental condition and behavior. She showed more confidence in herself and the tempo did not appear so retarded.

Doctor Woodhall's final statement about this patient follows: "To this date, it is my impression that the child has been definitely improved by the two-stage operation upon the skull. A glance at her photographs on November 5, 1940, as compared with Sep-

tember 1, 1941, shows, I believe, a definite change in the child's appearance, and certainly in the amount of exophthalmos. The child can no longer protrude the eyeballs in her gruesome manner. Electro-encephalograms show very definite release of pressure and we have been very pleased with the cessation of her convulsions, without any type of anticonvulsant therapy. Finally, although the psychometric test is somewhat discouraging, at least she has progressed with her age-group, although she is starting at a low level. The social service workers in Greensboro are planning to place her in school for the first time in her life, and the child herself is very eager to start her learning." The author believes that this patient's mentality might not have been so impaired had it been possible for this operation for oxycephaly to have been performed when she was three or four years of age.

A B

FIG. 11.—Case 4—T. C.: (A and B) Photographs made several days after the completion of the second stage of the operation. Exophthalmos considerably lessened.

Doctor Woodhall has completed a third case, and has performed the first stage upon two other cases, but he did not consider that these cases were ready for presenting at this time. Dr. R. F. Slaughter, of Augusta, Ga., performed this operation in three cases and stated that improvement followed operation in each case.

In addition to the characteristic changes associated with oxycephaly, all cases showed some degree of hypopituitarism, more marked in the older children. It is suggested that this condition is due to the constant and prolonged increase of intracranial pressure exerted on the pituitary body and the sella turcica. In all cases before operation, roentgenograms showed deep, narrow sellae. In Case 1, observed for a period of five years since the operation, the present roentgenograms reveal a sella normal in appearance, much wider in the transverse than in the vertical diameter, in contrast to the reverse measurements in the preoperative films. In a discussion, it has also been suggested that the healing of the malunited fracture (pseudo-arthrosis) subsequent to the open reduction performed after the first stage of the operation for oxycephaly in Case 1, after failing to occur preoperatively following performance of five operations for the same condition in the femur, was connected in some way with a changed condition in the pituitary body. It was considered that this change in the function of the pituitary body might have

resulted from the relief of the compression of the pituitary body by the wide decompressive effect afforded by the operation. This suggestion is made as a possibility, and not as a firm belief.

Sufficient evidence is presented to warrant the use of this operation in cases of true oxycephaly. It is advised that the operation be done before failure of vision and marked changes in mentality occur. This procedure may be of value in microcephaly. It might also be of value in the treatment of children with partial obstruction of the aqueduct accompanied by a mild degree of internal hydrocephalus, as suggested by the marked increase in the size of the skull in arrested cases which reach adulthood.

SUMMARY AND CONCLUSIONS

(1) Oxycephaly and allied conditions of the skull due to premature closure of the suture lines, without operation, terminate in blindness, dulled mentality and death, unless spontaneous arrest of the condition intervenes.

(2) An operation was proposed by the author, and performed for the first time in 1936. This operation may be undertaken in two stages, or in one stage, if circumstances permit.

(3) A description of the operation is given.

(4) A report of four cases is made. Case 1 was operated upon five years ago. A brief follow-up report of this case is made, substantiating beliefs stated in the preliminary report published in 1938. Immediate improvement has followed in all cases operated upon.

(5) Reference is made to other cases improved by operation, but not reported in this paper.

(6) Hypopituitarism associated with these conditions may be affected by the diminution of the increased intracranial pressure afforded by the operation.

(7) The procedure is *not* advocated in cases of microcephaly, or idiocy.

(8) Good results should follow performance of this operation in cases of *true* oxycephaly.

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DISCUSSION.—DR. BARNES WOODHALL (Durham, N. C.): We have had the opportunity of operating upon three children with oxycephaly, using the procedure described by Doctor King. We have been pleased with our results as compared with those obtained previously with the use of subtemporal decompression. In all cases, the vertex deformity so characteristic of oxycephaly has been obliterated and a normal contour of the skull has been reestablished. In each instance the circumference of the skull has increased, the increase following operation in one case measuring some 4.5 cm. The most striking evidence of the relief of increased intracranial pressure by morcellation of the skull is found in a comparative study of electro-encephalograms taken before and after operation. Before operation, studies of cortical activity show distorted forms with unstable frequencies, with large three-per-second waves in all leads. Following operation the records have returned to normal. In each case, the diminution in visual acuity, which may be so profound in oxycephaly, has been checked over a postoperative period of observation of some two and one-half years, and in one instance vision has improved. In one case, convulsions which had been present for a period of some ten months prior to operation ceased following operation and have remained absent for a period of 11 months without any other type of anticonvulsant therapy. Finally, the parents of these children affirm that they have ceased to complain of headache and visual loss and they are much more normal in every respect.

In our observation of some five cases recently, we have recognized two distinct forms. The first is that of true oxycephaly, with the characteristic deformity associated with a beak-like nose, hypoplasia of the maxilla, prognathism and occasionally with deformities elsewhere in the body. The second type is the so-called delayed oxycephaly, with the characteristic deformity and skull changes without the other features of true oxycephaly.

In our colored slides I have endeavored to illustrate this second type of oxycephaly. The first stage morcellation of the skull as carried out by us is also illustrated. We have not seen fit to undertake the procedure in one stage in these older children but, undoubtedly, as Doctor King has pointed out, a one-stage procedure could be advantageously and safely carried out in an earlier and younger case. In our experience, morcellation of the skull appears to be an ideal procedure for the relief of oxycephaly.

TREATMENT OF COMPOUND FRACTURES OF THE SKULL *

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THE PURPOSE of this paper is to emphasize the importance of early operation in the prevention of infection and to discuss certain technical procedures which, from personal experience, have been found most effective in the treatment of compound fractures of the vault of the skull.

The discussion does not include fracture of the base of the skull which is usually compound through the cranial sinuses, nor penetrating wounds produced by gunshot or other agents. The situation created by compound fractures of the base of the skull, because of their usual inaccessibility, is often a most complex one, totally unfavorable to effective surgery.

The frequency of open wounds of the head and the benefits of surgery in the prevention of infection give to these wounds an importance far exceeding that of any other surgical lesion produced by head trauma. Open fractures of the vault of the skull should present few problems of management to those familiar with such injuries but unfortunately they are often inadequately treated.

The prevention of infection is dependent on removal of contamination by early operation, and we believe there should be no delay in disinfecting these wounds beyond that necessitated by the patient's general condition. A delay of more than eight hours is rarely required. If infection is prevented the mortality is low, cerebral scarring is minimized, and epilepsy as a late result is much less likely to develop.

The principle of early, thorough operation within the first few hours after injury has been widely accepted as fundamental in the management of these cases, but there is not complete agreement. Review of recent literature discloses that a delay of 24 to 48 hours between the injury and operation is recommended by Munro,[1] in all cases of compound fracture of the skull. If operation is not undertaken within 48 hours, he advocates a further delay of from three to six months. It seems difficult to justify a delay of at least 24 hours in all cases when surely infection will develop in many of these contaminated wounds and may lead to fatal intracranial complications. We can see little reason for operation upon those who survive three to six months unless perhaps as a belated effort to prevent or control epilepsy or to eradicate osteomyelitis. Certainly, it would seem that the opportunity for rendering the greatest service to the patient may be lost by delay. It being impossible to predict the hour when infection will begin in a contaminated wound, the only safe course in such an uncertain situation is to remove those factors which lead to infection as soon as the patient's condition permits. It is true that chemotherapy may retard the onset of infection but the sulfonamide agents

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should be considered merely a supplement to, and in no sense a substitute for, early, adequate surgical treatment.

It should not be assumed that patients with compound fracture of the skull are necessarily in a state of shock. Many of them with crushing fractures of the vault and extrusion of pulpified brain tissue through the scalp laceration are conscious, alert, and in good general condition on admission to the hospital. Shock may be present from loss of blood or severe associated injuries but an analysis of a large series of consecutive head injury cases in my clinic has shown that the incidence of shock, as determined by clinical observations and blood pressure readings, was less than 10 per cent of the total number admitted to the hospital. When the injury is confined to the head shock is even more unusual. A high percentage of compound fractures, therefore, may be safely operated upon within the first eight hours, and our records show no instance of shock developing from early operation for compound fracture of the skull. We do not fix an arbitrary time limit for operation in cases when delay is unavoidable from shock due to associated injuries or late admission of the patient to the hospital. These cases must be individualized and some of them, if given early chemotherapy, may be successfully operated upon for the prevention of infection at a much later period than was formerly thought possible. Success of delayed operation in some of these cases, when such delay is absolutely necessary, in no way invalidates the arguments for early operative treatment in patients whose general condition is good and, in our experience, the large majority fall in this class.

When shock is present the treatment obviously should be directed to this condition and except for the arrest of external hemorrhage by simple means, no local surgical treatment of the head wound is permissible. The hair should be clipped about the laceration, sulfanilamide powder freely dusted in the wound and a sterile bandage applied. Transfusion may be necessary. It is of the greatest importance that shock is not increased either by ill advised surgery of the head wound or the injudicious management of associated injuries. Manipulation of fractured long bones, unnecessary handling of the patient or roentgenologic examination should be postponed until the patient has recovered from shock.

Operation for compound fracture of the skull will vary from disinfection, débridement and suture of the scalp laceration overlying a compound linear fracture, to a very extensive procedure in severe cases with brain laceration from indriven fragments of bone, requiring thorough débridement of scalp, bone, dura, and brain. However, the underlying principles of treatment are the same in all open wounds of the head.

Thorough disinfection and débridement of scalp lacerations are most important features of the operative technic of compound fractures. Some years ago we substituted irrigation with normal saline or Ringer's solution for chemicals in the disinfection of simple scalp lacerations. The effectiveness of mechanical removal of contamination by large quantities of nonirritating solution was amply demonstrated by Cushing[2] in the treatment of penetrating brain wounds

during the First World War. His results had much to do with the adoption of similar methods for disinfection of the associated scalp and bone injury.

Roentgenologic examination, which is a routine preliminary to operation, may show marked depression of the bone fragments. Extruded brain tissue is often seen matting the hair about the scalp wound. Patients with a crushing fracture in the frontal region and severe damage to the brain from indriven fragments of bone are frequently conscious on admission. The state of consciousness in these cases may be contrasted with that in more common types of injury in which the patients receive a heavy blow on the head which may or may not produce a linear fracture but does cause immediate and more or less prolonged unconsciousness. The explanation of retention of consciousness in cases of depressed fracture may well lie in the fact that the giving way of bone in the depressed fractures acts as a shock absorber to the impact and restricts the effects of the concussional force to the region of the injury.

Local anesthesia should be used whenever this is practicable, and we do not hesitate to give morphine to quiet a restless patient at the time of operation if the examination does not indicate increased intracranial pressure. Intracranial pressure is often spontaneously relieved in cases with lacerated dura by the extrusion of blood clot and pulpified brain tissue. Iodine and alcohol may be applied around but not used in the wound. Novocain solution, 1 per cent, with three drops of adrenalin to the ounce of solution, is then injected in the scalp around the wound. The scalp laceration should be freely irrigated with Ringer's or saline solution and the laceration débrided back from its edge for at least one-eighth inch. After this is done the wound is again irrigated. The fracture should be carefully inspected and if it does not appear to be contaminated and is not depressed, no treatment of the fracture line is indicated. In some cases there may be obvious contamination of the fracture line with foreign matter such as hair and grit caught between the bone fragments. When such is the case it is necessary to excise the contaminated fracture line with a narrow rongeur to permit complete disinfection of the wound. The suture of a disinfected scalp laceration, usually considered a minor procedure, has been called by Colonel Cairns, of the British Army "the most important cranial operation of war." After complete disinfection and débridement the scalp laceration is sutured in all cases in two layers with interrupted fine silk sutures. The whole treatment of compound linear fractures in the large majority of cases consists merely of adequate disinfection, débridement and suture of the overlying scalp laceration.

It may be necessary to enlarge the scalp wound after it has been disinfected and débrided in order to give better access to the fracture. When the fracture is exposed the depressed fragments often may be removed with little difficulty but in some cases the fragments are locked and require a bur-opening adjacent to one of the fracture lines and the rongeuring away of a small area of bone to free the impacted fragments.

Usually there is very little hemorrhage in removing the bone fragments but when the fracture overlies a large venous sinus one must proceed cau-

tiously and be prepared to deal with formidable hemorrhage should one of the venous sinuses be punctured by a spicule of bone. The application of muscle grafts is the most effective way to control hemorrhage from one of these sinuses but much blood loss may result before the bleeding is stopped. In one such recent case the patient was practically exsanguinated on admission and died from hemorrhage from the sinus before the laceration of the sinus could be exposed.

If the exposed dura shows no laceration, one should attempt to determine whether there is underlying hemorrhage caused by the fracture. A bluish discoloration of the dura indicates there is subdural bleeding and if operation is undertaken early after injury it may be safe to open the dura and remove the clot and macerated brain tissue by irrigation and suction. However, if there is doubt as to the completeness of disinfection of the wound, the dura should not be opened unless demanded by evidence of considerable subdural bleeding which would necessitate the removal of accumulated blood and control of subdural hemorrhage.

There is no general agreement regarding replacement of bone fragments in compound fractures of the skull. In some cases we have replaced the fragments on the dura with firm healing in a few weeks. The chances for healing of the replaced fragments without infection are perhaps increased with chemotherapy but if one is not reasonably sure that they are free of contamination, or if the operation has been delayed beyond 12 hours, it would seem best to discard the fragments. As a rule, it is inadvisable to replace the fragments when there has been laceration of the dura with severe injury to the brain.

When the dura is lacerated and there is localized injury to the brain, the macerated brain tissue, blood clot and other loose débris may be removed by irrigation and the suction force of a bulb syringe, but this can be done more effectively with the suction apparatus. With about eight to ten pounds of suction pressure, all lacerated tissue and blood clot can be removed down to the healthy brain tissue. This may be done under direct inspection even though the brain wound reaches a considerable depth. In some cases, penetration by spicules of bone causes a subcortical hemorrhage, which leaves a cavity of moderate size in the brain after the clot has been removed. With a lighted spatula the brain wound may be inspected in all of its recesses for the removal of débris and exposure of bleeding vessels. Hemorrhage is controlled by coagulating the vessels with the electrosurgical unit after drawing them into a glass suction tip. This is a most satisfactory method of dealing with hemorrhage in the depths of a brain laceration. After the brain wound is thoroughly cleansed by irrigation and suction, and all bleeding arrested, it is filled with Ringer's solution. We make a practice of closing the dura in all cases. It may be necessary to use a small graft of pericranium, galea or temporal fascia or even fascia lata to secure tight closure. Repeated irrigations are required throughout the operative procedure for compound fractures of the skull.

Crushing fractures of the skull in the frontal region frequently involve one

or both frontal sinuses and the fracture line may radiate along the base through the ethmoid and sphenoid sinuses. Fracture through the frontal sinus is of no especial significance in the production of early infection unless the adjacent dura is lacerated. Should the sinus later become infected, the patient would be exposed to the same intracranial complications as may follow sinus infection from any cause. In many cases of compound vault fractures there is marked comminution of the wall of the frontal sinus with extensive laceration of the dura adjacent to the sinus and under the frontal lobe, from fractures radiating backward through the ethmoid. The procedure we have followed in such cases is, first to disinfect thoroughly the scalp laceration and brain wound, then repair the dura securely. After tight closure of the dura, using a graft if necessary, the detached bone of the sinus wall and the mucous membrane should be completely removed. The sinus is then packed with iodoform gauze. No drainage material is inserted into the dura in the treatment of any type of compound fracture, and, in our opinion, it should be avoided, especially when the fractures involve the frontal sinus.

There appears to be no uniform practice with respect to intradural drainage in severe fractures of the vault involving the frontal sinus. Cone[3] recommends intradural drainage with the drain emerging in the lower anterior temporal region. Munro[4] inserts a conical wire mesh drain through the dural laceration into the defect made by "cortical excision." We have acted on the belief that cases involving the frontal sinus and requiring operation on the sinus are especially unfavorable for any drainage material which passes into the dura. Assuming that the brain wound has been thoroughly disinfected, it appears to the writer that the most important step in the technic of operation in these cases is the secure closure of the dura without drainage. In all cases in which the dura has been opened, we start sulfanilamide promptly but we have not used it locally within the dura in any type of intracranial operation.

In compound fracture of the vault with radiation of the fracture lines through the frontal and ethmoid sinuses, a cerebrospinal fluid leak may persist from faulty repair of accessible dural lacerations and also in cases in which the tear of the dura is inaccessible. The sole surgical indication in fractures of the base of the skull is to close a cerebrospinal fluid leak. These injuries are not considered in this paper but it may be mentioned that we use chemotherapy promptly in all cases with leaking cerebrospinal fluid from any cause. Chemotherapy will very likely obviate, to a great extent, the necessity of operation in cerebrospinal rhinorrhea from basal fractures.

The same nursing care is required for patients after operation for compound fracture as for any other type of severe head trauma. In cases with pulmonary complications it may be necessary to keep the patient in a lateral prone position with the foot of the bed elevated for a considerable part of the time to relieve obstruction of the air passages by bronchial secretions. Infection should be prevented in practically every case of compound fracture of the

skull, and the results of operation for compound depressed fracture with laceration of the dura and extravasation of brain tissue are surprisingly good.

In a series of more than 2,000 consecutive head injuries admitted to the hospitals of the Medical College of Virginia from 1935 to 1940, inclusive, there were 224 compound fractures of the skull, with a gross mortality rate of 16.5 per cent. Of this number, operation upon the skull for depressed fracture or contaminated linear fracture was necessary in 105 cases, with an operative mortality of 11.4 per cent. Of the entire group of 224 fracture cases there were 40 with severe associated injuries not including those of the facial bones. As was to be expected, the highest mortality was found in this latter group.

A cranial defect of considerable size may result from the operative treatment of compound depressed fractures. For many years we have repaired cranial defects for deformity in the frontal region, and because of the patient's fear of injury to the unprotected area, or when certain subjective symptoms are present which might be attributed to fluctuation of the brain mass from sudden change of position.

After a rather extensive and disappointing experience with the use of thin bone grafts from the outer table of the skull, we have used thick, perforated celluloid plates with excellent results as a substitute for autogenous grafts.[7] Celluloid plates may be molded to the contour of the skull by boiling the plates between the curved surfaces of two bowls. We have seen only one infection from celluloid plate in a large series of cases and this infection resulted from its application over a defect which involved the frontal sinus. A cranial defect should not be repaired until several months after the wound has completely healed. Intracranial pressure and retained foreign bodies are well known contraindications to cranioplasty. Vitallium[6] and other foreign materials have been used for cranioplasty but they appear to possess no advantage over celluloid.*

Cranioplasty with autogenous grafts from the outer table of the skull was described by the writer[5] in 1919. This report was based on a large series of cases operated on in the Cape May Hospital (U.S.A. Hosp. No. 11). The end-results of only a small number of these patients are known but it was clearly evident from those examined after their discharge from the army that this type of cranioplasty was unsatisfactory or a complete failure in many cases. Many autogenous grafts fail to survive and of those that do, there is usually sagging in large defects of the vertex. A very serious objection to autogenous grafts from the outer table of the skull is that it requires a tedious and difficult operation to procure the graft. I know of no operation which has less precision or may be more annoying than an attempt to remove the outer table of the skull to repair a large defect. In addition to the difficulties

* The use of celluloid plate for the repair of cranial defects was described by Dr. William Perrin Nicolson at a meeting of this Association in 1904. At another meeting, 20 years ago in this hotel, Doctor Nicolson made further reference to the advantages of celluloid plate in the repair of cranial defects, stating it had been used by him constantly since his first report. In a rather humorous way, Doctor Nicolson stated, "The only surgical objection I know to its employment is the fact that it is too easy and simple to do."

of the procedure, one must seriously question the propriety of a prolonged session on the skull of a live human being with a hammer and chisel.

Sections of ribs have been used to repair cranial defects. When the defect is in the frontal region, repair with rib or rib cartilage is unsatisfactory from a cosmetic standpoint and cranioplasty by this method is also a troublesome procedure. Among the autogenous grafts, perhaps those from the ilium are the most satisfactory.

Except for its cosmetic effect, the relief of certain subjective symptoms and the sense of protection it gives the patient, there is no other indication for the repair of cranial defects. We believe that all of these indications for cranioplasty can be met by the use of celluloid plate and there seems little justification for doing a long, tedious procedure when a more simple one will suffice.

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DISCUSSION.—DR. CHALMERS H. MOORE (Birmingham, Ala.): Doctor Coleman's discussion of compound skull fracture was of especial interest to me for two reasons: First, our methods have been diametrically opposite; and second, because our results very nearly parallel each other. We have preferred to consider that the great majority of these cases are either in shock at the time of admission, or in potential shock. If operation is undertaken too early, one never knows to what depths he may have to go, and a potentially shocked patient may well be carried into profound shock. To be sure, there is local infection present at the time of injury, but the bacteria do not spread through the tissues in 24 hours. The results following delayed operation, considering sepsis as the primary problem, have shown a greatly reduced mortality rate; the incidence of infection is not more than 3 per cent, and that has been reduced by the use of sulfanilamide. We do not hesitate to fill the wound with powder.

The lacerated scalp wound is inspected, and the sterile finger used to determine the presence of an underlying fracture. This is more definite than the roentgenogram. If the skull is fractured, nothing more is then done except to fill the wound with sulfanilamide, apply a dry dressing, and institute treatment for shock if necessary. Twenty-four hours following injury is the optimum time to operate; there is no need to wait past that time unless of course some contraindication exists, such as severe associated injury. This is often the case. If necessary to postpone operation beyond 48 hours we, with Munro, have reached the conclusion that it is better to let the wound heal by granulation and carry out any necessary operative procedures several months later.

We feel very strongly that many instances of potential shock will be prevented from going into profound shock by waiting 24 hours.

RECENT ADVANCES IN THE DIAGNOSIS AND TREATMENT OF RUPTURED INTERVERTEBRAL DISKS *

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THERE can be few more remarkable examples of the excellent results that accrue from intelligent intensive cultivation of a surgical field than that of ruptured intervertebral disks. Twelve years ago a ruptured intervertebral disk was unknown.[1] Now it is a clinical entity, with precise definition, surprisingly common, and curable by operative means, without risk or loss of bony structure. Neurosurgeons now see more ruptured intervertebral disks than any other lesion.

This entity accounts for an overwhelming percentage of the hitherto incurable and untreatable low back pains and sciaticas, and miscalled sacro-iliac strains, arthritis of the spine, *etc.*—all of which must have been anathema to orthopedists. To have reached the present stage in diagnosis, it is to be expected that many diagnostic tests should have been introduced and subsequently become unnecessary. And it is equally obvious that the operative treatment should have become greatly simplified.

At first, this lesion was localized by injecting small amounts of lipiodol into the spinal canal. For the detection of the smaller protruding disks by filling defects, large amounts (5 cc.) of this substance were introduced by Mixter and Barr[2] (1934). Unless subsequently removed, lipiodol is a permanent deposit in the subarachnoid space—both spinal and intracranial—and also has free access to the entire ventricular system. Reichert[3] (1937) introduced air as a contrast medium in order to avoid the huge masses of lipiodol. With good roentgenograms and excellent interpretation of the air shadows, the results were almost as satisfactory. The most important advance was attained through a statistical study of these lesions. Simultaneously, and with identical results, and appearing in the same issue of the Archives of Surgery (1940), Love[4] and Spurling[5] found that 96 per cent of all spinal ruptured disks were situated at the fourth and fifth lumbar vertebrae. And if only lumbar disks were considered, over 98 per cent were in these two situations. This at once simplified the localization of the lesion to one of almost absolute precision, and entirely eliminated the need of spinal contrast media for its *localization*. However, this fact did not alter the need for a means of *diagnosing* the lesion. Semmes[6] (1939), emphasizing the characteristic clinical picture of ruptured disks, suggested that no spinal injections were necessary. He reported 16 consecutive cases operated upon without contrast media or other tests, and at operation found disks in all cases.

Three important advances have improved upon, and greatly simplified, the operative treatment. Originally, a bilateral laminectomy was performed and the disk removed intradurally. (1) Mixter and Barr (1934) removed the

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disks extradurally, but still used the bilateral approach. (2) Semmes (1939), and shortly afterwards Love[7] (1939), reported their removal by hemilaminectomy and by removing only a notch of bone in a lamina, and, finally, (3) Love[4] (1940) removed a high percentage of ruptured disks through the interlaminal space without removing any bone whatever. Love's procedure is the acme of perfection, but can be accomplished only when the variable space between the laminae is of sufficient size. Practically, it does not matter whether a small bite of a lamina is removed for better exposure. In a recent case I removed a ruptured disk without sacrificing any bone whatever, but also without removing the ligamentum flavum. This, however, is probably of no practical import.

CONCEALED VERTEBRAL DISKS

In a recent publication[8] the writer disclosed a variation of this lesion which was called a "concealed disk," and which represents about one-fourth of the total number. Symptomatically, there was no difference whatever in the subjective or objective manifestations, but at operation the detection of the lesion was much more difficult. The end-results in treatment were precisely the same. A concealed disk is one that protrudes so slightly that it could hardly be found at operation unless one explored the subdural region with great care, but at the same time the findings are just as definite and unequivocal as the large protruding disks. Always, there is a very tiny bulge of the intervertebral space, with thickening of the spinal ligament; it indents with pressure of the forceps, and gives a sense of fluctuation to the pressure by them. And when incised, the forceps dip deeply into a cavity in the disk. When a curette is introduced macerated vertebral disk is obtainable. In none, however, does a sizable sequestrum of cartilage extrude through the opening. At times the concealed disk is laterally placed, at other times, at or near the midline. In every case the emerging nerve has been quite adherent to it, and this attachment is, I think, responsible for the pain; perhaps an intermittent protrusion of the disk may be a factor, but there is no proof of this, and the seemingly inelastic nature of the ligamentous capsule would appear to deny it.

There are always two component parts of a ruptured disk that are responsible for the patient's symptoms: (1) The necrotic interior of the disk, under pressure from edema, causes the backache; and (2) the protrusion upon, or adherence to, the emerging spinal nerve causes the sciatica.

The realization of these two elements is necessary for the certainty of a cure. A large protruding disk may be withdrawn and still not cure the symptoms. It is all-important that the interior of the disk be opened. It is not necessary completely to remove the contents of the ruptured disk to produce a cure—that is in fact impossible—but it is necessary to open it as widely as possible in order that the nonviable content, *i.e.*, the sequestrum, may be subsequently extruded through this opening. The principle in treatment is not unlike that of an abscess although the fundamental pathology is in no wise similar. There is no infective basis for an intervertebral disk. Always, it is a traumatic after-effect, and curiously, the trauma is always relatively slight.

Curiously, a severe traumatic rupture of the spine never causes a protruding disk. The explanation is, I think, that with severe injuries the ligament over the dorsal surface is torn and provides the vent for its cure, much like that the surgeon produces by incising this ligament and opening the interior.

A ruptured vertebral disk is one of the most satisfactory lesions to treat surgically. When properly treated a cure can be expected in almost every case, and spontaneous cures, or treatment by braces, *etc.*, must be rare indeed. Recurring attacks are to be expected throughout life, or at least for many years. From the postoperative follow-up reports in the literature there have been 5 per cent recurrences. So far, I have not had a recurrence. This may be just a fortunate series, but I am inclined to believe that the explanation of recurrences is the failure to open the cavity in the body of the disk. Cures may result almost immediately, or they may take several weeks or even months; the difference, I think, is due to the time required for the complete extrusion of the affected disk. Bony fusion has been recommended by some operators, but this is neither necessary nor advisable. Patients should perhaps wear a brace for three months after operation, and should avoid heavy lifting and back strains during this time; thereafter they may continue in any occupation.

The diagnosis of ruptured intervertebral disks is now one of the greatest simplicity and accuracy from the symptoms alone. The characteristic story is: (1) Low back pain; (2) spreading down the posterior aspect of one, or at times both legs; and (3) intensification of the pain in the back and leg by coughing or sneezing. The only item of importance in the examination is the reduction or loss of Achilles reflex on the affected side. At times there may be hypo-esthesia along the course of the affected nerve. Given this story, there can scarcely be any other lesion that need be considered. The pain begins after a heavy lift, a sudden twist of the spine, or an accident to the spine, or the trauma may even pass unnoticed. Movements of the spine intensify the pain. The pain is usually in recurring attacks, with more or less free intervals between, but the pain may be continuous, and in many cases it eventually becomes constant. With continuous pain, a psychoneurosis is a possibility; this and very occasional tumors (I have encountered one) are almost the only lesions that need be considered in differential diagnosis. At times the pain may be in the sacro-iliac region on one or both sides; occasionally there may be no back pain, and intensification of the pain by coughing and sneezing may be absent, but when present it leaves no doubt of the organic nature of the pain when a psychoneurosis is under consideration. The presence of normal Achilles reflex means nothing; the reduction or absence means a great deal; its loss may be referable to either the fourth or fifth disk.

Another anatomic factor must be borne in mind, namely, the not infrequent occurrence of a sixth lumbar vertebra, and when present the ruptured disk will probably be at the sixth disk. Two of our cases, in this recent series, occurred in this position; it was only at the operation that the sixth vertebra was recognized and subsequently checked roentgenologically.

I am particularly anxious to emphasize the purely clinical diagnosis, and to deprecate the use of all contrast media in the spinal canal, even to avoid spinal punctures. In the first place, these procedures are not necessary; they add nothing but the actual visualization of a lesion that is perfectly well known. They are painful procedures, and no one would desire a permanent deposit of lipiodol in the central nervous system. It is true that much of

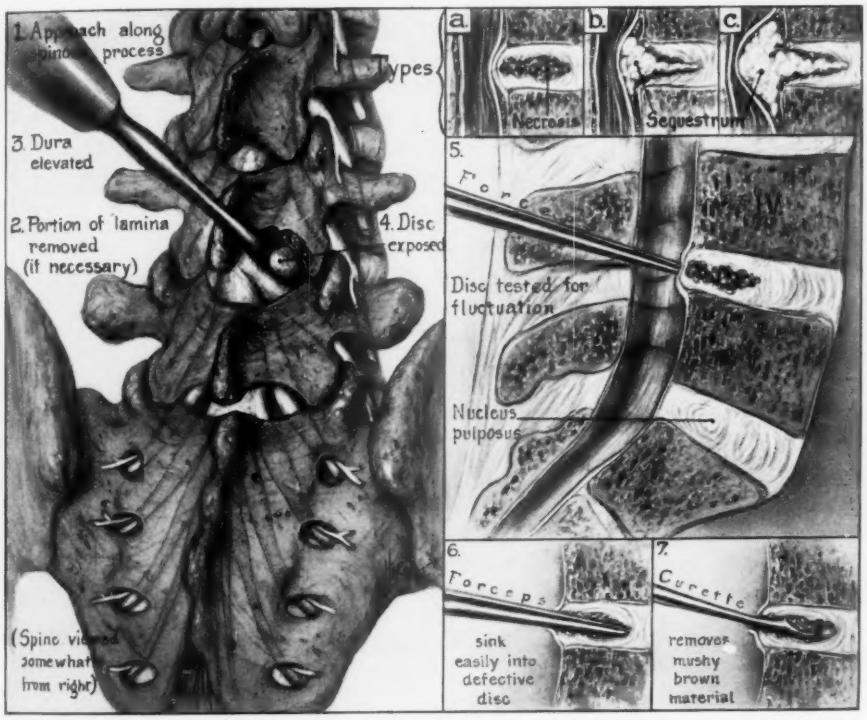

PLATE 1.—Drawings showing the methods of attack upon ruptured intervertebral disks (figure on left). Frequently the removal of this small portion of bone is not necessary (Love's procedure). The figures on the right show the three degrees of protrusion of the vertebral disk (a, b, c). Figure 5 shows the very slight elevation of a concealed disk and the indentation by pressure on the posterior spinal ligament. Figure 6 shows the defect in the disk itself. It is the wide opening of this that is necessary for the cure of the disk, whether of the protruding or concealed types. Curettement of the interior of the disk is not necessary, but in the concealed type one may obtain necrotic cartilaginous remains from the cavity. I see no reason to believe that the nucleus pulposus has any relationship to this lesion which involves much of the interior of the disk.

the lipiodol may now be removed at the time of operation, or when operation is not performed, by another puncture and aspiration, but the latter may be only partially successful and is, again, very painful.

The most important reason, however, for avoiding spinal contrast media is that the results are frequently negative when an actual ruptured disk is present. It is here that the "concealed disks" are all-important. None of them can possibly show a filling defect in either the air or lipiodol shadows; and concealed disks are more than 25 per cent of the total number. If lipiodol is used, and is negative, it means that these patients are excluded from the operative treatment that is essential for a cure; and without lipiodol

they are diagnosed with ease and certainty solely by analyzing the patient's symptoms.

It is the recognition of the concealed disk that has completed the solution of this problem which approaches 100 per cent in accuracy of diagnosis. Before they were known there was a corresponding percentage of negative explorations, or, if lipiodol was used, a similar percentage of patients who were denied operation.

Since the elimination of contrast media, we have had (since April 1, 1941 to the time of this presentation, December 10, 1941) by clinical examinations alone, 63 cases without a single mistaken diagnosis. Lipiodol and air injections into the spinal canal, therefore, do far more harm than good, and their avoidance is most enthusiastically welcomed by the patient. In view of the fact that 96 per cent of all vertebral disks are at the fourth, fifth (and sixth) lumbar spaces (the percentage of the lumbar disks that are at these spaces is even greater), and since the unilateral approach is adequate to disclose the disk, regardless of the interspace involved, it only remains to make the diagnosis of a lumbar vertebral disk, and this is almost pathognomonic from signs and symptoms alone.

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DISCUSSION.—DR. CHALMERS H. MOORE (Birmingham, Ala.): The story of the extruded disk constitutes an important chapter in the history of surgery for relief of pain. After Dandy first reported this condition, in the late nineteen-twenties, interest in the subject lay dormant for several years. Recently, however, the literature has contained many references to the condition. There is no doubt that the disk accounts for much of what was formerly erroneously called sciatica. I am familiar with a series of 200 cases which fall into two groups, one, in which compensation was a factor, and the other, in which compensation was not a factor. In the first group, 85 per cent of the results were poor; the patient still complaining of his preoperative pain. Whereas in the noncompensation group, over 90 per cent experienced relief.

This percentage runs about the same in my own series of 32 cases. Therefore, this compensation factor, present in so many cases, particularly in an industrial region such as Birmingham, must be borne in mind in evaluating results in this condition, which is now being recognized with such increasing frequency.

DR. GEORGE E. BENNETT (Baltimore, Md.): It is a great pleasure for me to have the opportunity to say a few words about Doctor Dandy's discussion on intervertebral disks, and particularly in regard to diagnosis and treatment. The orthopedists have often referred to sciatica as a "headache." There is no bone or joint lesion which gives us more concern. Needless to say, we are all pleased that another etiologic factor has been definitely proven a cause of low back pain and sciatica.

I, fortunately, have lived long enough to have seen many cures developed for sciatica and low back pain. When I joined Doctor Baer, in 1910, he was manipulating a great number of patients for low back pain and sciatica, feeling that there was probably some displacement of the sacrum or the sacro-iliac joints. In 1914, we checked over approximately 200 of these cases and found that 40 per cent of them were cures. We were able to differentiate, and practically predict, the type of case that would be relieved by manipulation. It is a procedure that we use at present but we do not use it as indiscriminately as we did 25 years ago.

The next procedure that came into prominence was arthrodesis of the sacro-iliac joint for low back pain and sciatica. This is a procedure which is effective when one has a definite lesion of the sacro-iliac joint which is responsible for the pain and, in well selected cases, a high percentage of excellent results is obtained.

Next in order came the fusion of the lumbosacral articulation for the supposed slipping of a facet in an unstable spine, with local and referred pain. I can recall a very prominent orthopedic surgeon making the statement, some 15 years ago, that this was a cure for sciatica. This is a procedure which offers a very high percentage of very satisfactory results in those cases which are the result of abnormalities, *etc.*, which one sees about the fifth lumbar vertebra and the top of the sacrum.

In more recent years, Freiberg called attention to the fact that the pyriformis muscle in certain selected cases was the cause of sciatic pain. When one sees a patient with a definite pyriformis syndrome it is just as rational to divide the tendinous insertion of the pyriformis muscle as it is to operate upon the scalenus anticus for referred pain to the arm. There is a definite place for this operation but it is not the cure for all cases of sciatica.

Doctor Ober has also recently called attention to the shortening of the tensor fascia lata and advised division of this as a cure for sciatica. Only a few years ago, at a meeting of this same organization, a paper was read on this subject and many cures were reported. Again, this is a procedure which works very satisfactorily in the type of sciatica which is caused by shortening of the tensor fascia.

I think Doctor Dandy's observation of many years ago that cartilaginous injuries would produce sciatic pain is a great contribution, and that he and other neurosurgeons who have developed this field are to be congratulated. They have added one more definitely proven pathologic process which is productive of low back pain and sciatica, but I do believe that a careful, differential diagnosis is very essential before operation is recommended, and that it is not a procedure that should be used indiscriminately.

Dr. Joseph E. J. King (New York, N. Y.): I want to say first that I agree with everything Doctor Bennett stated. I was very glad that Doctor Mixter's name was mentioned, as I do not think the question of herniation of the disk should be discussed without mentioning the names of both Doctors Mixter and Alfred S. Taylor. It is to Doctor Taylor we are indebted for the hemilaminectomy, and inasmuch as most of the disks occur in the lumbar and cervical regions, the hemilaminectomy popularized by Doctor Taylor suffices.

I have had very little help from the use of air, and have almost come to the conclusions reached by Doctor Dandy, namely, operation without any contrast medium. On the other hand, it is very convincing to see the deformity in the lipiodol column produced by the disk. However, once lipiodol has been instilled in the subarachnoid space, it should be removed, inasmuch as it "beads" around the component parts of the cauda equina if not removed. I have seen this condition in three instances. I understand the major portion of the lipiodol can be removed by aspiration through a rather large lumbar puncture needle, with the patient lying on the abdomen. This has been demonstrated by the men in Boston.

I was glad to hear Doctor Bennett emphasize the fact that all low back pains are not produced by herniation of an intervertebral disk. In fact, only a small percentage of patients suffering from low back pain have herniated disks. There is a tendency to ascribe too many instances of low back pain to herniation of the disk. Several years ago it was the fad to believe that fusion was indicated in most cases of low back pain. Today one notices the tendency to attribute many instances of low back pain to herniation of a disk.

A number of writers have stated that hypertrophy or thickening of the ligamentum flavum may be present with or without a disk and may produce low back pain. I should like to ask Doctor Dandy his opinion on this question.

Dr. Walter E. Dandy (Baltimore, Md., closing): I shall only answer Doctor King's question about the ligamentum flavum. My friend Doctor Reichert, of San Francisco, described it, but I have never been convinced that a thickened ligamentum flavum can cause sciatica or low back pain.

Doctor Moore spoke of the functional disturbances simulating a ruptured vertebral disk. This is very important. One has to be on guard against the constant backache that always obtains in cases of malingering. The ruptured intervertebral disk causes recurring backaches and recurrence after slight trauma. This leaves no doubt about its organic nature. They may, indeed, malinger afterward, but the evidence should be clear.

GASTRIC ULCER, CARCINOMATOUS ULCER OR ULCERATING CARCINOMA? *

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IT WOULD SEEM TRITE to state that the therapy of any gastric lesion should be based on the pathologic nature of the lesion, on the recognition of the various mechanisms by which healing of the lesion is accomplished, and, when removal of the lesion is indicated, on the changing physiologic and chemical changes set up as a result of the surgical procedure employed to prevent recurrent ulceration. That certain benign gastric ulcers will heal under nonsurgical therapy properly carried out is well known. That such a group, however, cannot be so readily dismissed from our consideration as surgeons is evidenced by the fact that many such ulcers, even though benign in character, do not completely heal, but only seem to do so, and recur when the methods directed toward their treatment are discarded and the previous habits of eating and conduct of life are resumed. If such a cycle was confined only to those lesions suspected of being benign gastric ulcers, the seriousness of such lesions might be overestimated. That such is not the case, however, is evidenced by the fact that the same methods of evaluation which would seem to indicate healing of the lesion may also take place when the ulcer is cancerous, and an attempt to treat the lesion by nonsurgical methods when it reappears may delay surgical treatment until the lesion becomes inoperable. It is apparent, therefore, that one of our problems as diagnosticians and surgeons lies in trying to determine the pathologic nature of the lesion from the patient's history and physical examination and the reports of the roentgenologist and the gastroscopist. In many cases this is exceedingly difficult. Although the expert roentgenologist may recognize the presence of a gastric lesion in 98 per cent of cases in which it is present, he has emphasized repeatedly that there is a definite percentage of error in distinguishing a nonmalignant from a malignant gastric ulcer. This has too frequently been forgotten.

In a study of all of the patients operated upon for carcinoma of the stomach, between the years 1907 and 1938, inclusive, at the Mayo Clinic,[18, 21, 22, 23] although the roentgenologist recognized the presence of a gastric lesion in 99 per cent of the cases, an unqualified diagnosis of cancer of the stomach was made in only 75 per cent of the cases in which gastric resection was performed. A roentgenographic report of gastric ulcer was made in 10 per cent of the cases. The gastroscopist has aided us in recognizing the presence of lesions difficult to visualize roentgenographically, namely, those on the posterior cardiac portion of the stomach and some of those on the lesser curvature producing disturbances of motility suggesting that the lesion was duodenal

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owing to the associated pylorospasm. Even when the lesion is observable, the possibility of misinterpretation of the pathologic nature of the ulcerating lesion by the gastroscopist must be definitely emphasized as a possible source of error. It is because of these difficulties in making a differential diagnosis between benign and malignant gastric ulcers and because many of them do not reach the surgeon until they have become large ulcerating carcinomata or perhaps until metastasis has occurred, that I have thought it worth while to call attention to some of the other possible sources of error which confront us all in differentiating between the benign and malignant gastric ulcer.

In the annual oration for 1936, delivered before the Medical Society of London, Sir James Walton quoted Stewart's statistics, which are so important that I think they should be constantly kept in mind, especially since Sir James said that they are generally accepted. Stewart stated that 10 per cent of chronic gastric ulcers become carcinomatous, that 17 per cent of gastric carcinomata originate in chronic gastric ulcers, but the incidence is probably much higher since many ulcerating gastric lesions are so large, when examined pathologically, that it is difficult to determine whether or not they might or might not have originated in a gastric ulcer. According to Katsch,[7] 20 per cent of gastric ulcers become malignant, and Finsterer[4] found that the ulcer was carcinomatous in 141 of 532 cases in which resection had been performed for gastric ulcer, an incidence of "20.9 per cent." Recent studies in this country by Allen and Welch[1] revealed that cancer was present in 14 per cent of cases in which an original diagnosis of ulcer had been made. In a series of cases reported by Klingenstein[9] and Colp,[2] this incidence was 12 per cent.

Several years ago it was suggested that a therapeutic test could be made by subjecting patients who were thought to have benign gastric ulcers to a course of nonsurgical therapy, which consisted, for the most part, of neutralization of the gastric acidity, and of relief of pylorospasm and hypermotility of the stomach by complete rest and relaxation. Surgeons know the details of the nonsurgical methods directed to this end. It was thought that, if the symptoms subsided, the lesion disappeared in the roentgenogram, and blood disappeared from the stools, the ulcer was benign and it had probably healed. Experience has shown that these criteria of benignancy or even of healing have not stood the test of time, not only because many of the ulcers recurred as soon as the patient's dietary and physical restrictions, imposed during his stay in the hospital and during the ambulatory period, were discarded when the patient returned to work but because in a definite percentage of the cases the ulcers were carcinomatous. The recurrence of a chronic gastric ulcer treated by medical methods is quite understandable in view of the fact that unless complete control of gastric acidity can constantly be maintained, unless the associated gastrospasm or pylorospasm can be constantly prevented, and unless something unusual happens to that unknown condition called "tissue susceptibility" to recurring ulceration, and with the same acid factors present as existed before the medical treatment was instituted, recurrence of the lesion takes place.

Three weeks ago I sent a patient into the hospital for a three weeks' trial of medical treatment. Examination revealed a gastric ulcer high on the lesser curvature of the stomach. After being in the hospital for a week symptoms attributable to the ulcer completely disappeared and tests for blood in the stools were negative. At the end of the third week, roentgenologic examination indicated that the lesion had disappeared, but gastroscopic examination revealed that an ulcerating lesion still was present. In other words, had a gastroscopic examination not been performed the erroneous impression might have been reached that the ulcer had healed. On the other hand, I recently operated upon a patient in whom a malignant lesion of the stomach had been suspected, but roentgenologic examination, on two occasions, at the clinic failed to reveal the presence of a gastric lesion. Gastroscopic examination, on the other hand, apparently revealed an ulcerating lesion high on the posterior wall of the stomach just off the lesser curvature. At operation, both extragastric and intragastric exploration, under visual control, disclosed only a hypertrophic gastritis with some spotty, grayish exudate here and there between the hypertrophied gastric rugae. Although these cases are exceptions, both of them were observed in the course of one month. They indicate that one cannot always rely too much on the roentgenogram in determining the changing character of a gastric ulcer; likewise, the gastroscopist's interpretation of his findings is subject to the same possibility of human error. To emphasize the point further, I should like to mention another case in which roentgenologic examination revealed a sizable crater due to a gastric ulcer. Twenty-four hours later, a roentgenologic examination made under similar circumstances revealed that the crater was only half as large as it had appeared to be on the previous day. Naturally, such a degree of healing probably did not take place in so short a time.

According to Schindler,[15] the seeming disappearance, or the decrease in the size, of the crater when the lesion is malignant is due to the infiltration of the crater by the carcinomatous process originating in one edge of the ulcer, granulation tissue filling in the remainder.

At the present time, my colleagues, Priestley and Judd,* are studying a group of 170 cases, observed at the clinic between 1930 and 1937, in which a diagnosis of gastric ulcer was made and the patients were placed on a medical regimen. Many of these patients were operated upon later because of recurrence of the benign lesion and others for gastric carcinoma. Other similar studies of the permanency of supposed healing of chronic, benign gastric ulcer, when the patients have been placed on a medical regimen, should be carried out.

It may have seemed out of place to consider the so-called laboratory methods of determining the presence and the nature of ulcerating gastric lesions before considering the symptoms. I have done so purposely because I wish to emphasize the inconsistency of assuming that patients with benign ulcers of the stomach have symptoms which are characteristic of benignancy.

* Doctors Priestley and Judd will publish the results of their study when completed.

Such symptoms are frequently referred to as "the ulcer type of dyspepsia" and are characterized by burning epigastric pain that appears one to two hours after eating and is relieved by ingestion of food or bicarbonate of soda, or by emptying the stomach. These, according to Sippy, were more accurate in differentiating a benign and a malignant gastric lesion than the roentgenologic examination, as carried out at that time, 1919 and 1920, in his hospital. The fallacy of this viewpoint is evidenced by the fact that in 33 per cent of the cases of carcinoma of the stomach in which operation was performed at the clinic between 1907 and 1938, inclusive, the patients had an ulcer type of dyspepsia in almost a similar percentage of cases, this ulcer type of dyspepsia had been the first symptom which the patients had observed. Of even greater importance, it seems to me is the fact that in these cases medical treatment directed toward controlling the acidity and relieving gastrospasm was followed by effective relief of pain in 80.6 per cent of the cases. Several years ago I stated that it was my impression that 20 per cent of the patients upon whom I operated for carcinoma of the stomach had been treated medically for many months on the assumption, from their history, that a benign peptic ulcer was present and it was only when the patients had failed to obtain relief of symptoms by these measures that roentgenologic examination had been performed and revealed that the lesion was not a benign ulcer of the stomach or duodenum but a malignant lesion of the stomach. As a history suggestive of gastric ulcer is obtained in one-third of the cases in which operation is performed for cancer of the stomach, and since medical treatment produces symptomatic relief in 80 per cent of cases, it is quite apparent that the same difficulties in interpreting the pathologic nature of a gastric ulcer will be encountered.

In considering such a parallelism in symptoms of benign and malignant lesions of the stomach, one invariably wishes to know if a study of gastric acidity in such cases might not be helpful. The presence of achlorhydria in a case of ulcerating gastric lesion usually means that the lesion is malignant regardless of the roentgenographic report, but on the other hand a relative achlorhydria was present in only 51.4 per cent of the cases of gastric carcinoma in which resection was performed at the clinic and to which I have referred previously. In comparing the values for hydrochloric acid it was noted that in cases of both groups, namely, those in which resection was performed as well as those in which palliative procedures were carried out, free hydrochloric acid was present and that the values, as determined by the method of Töpfer, ranged from one to 29 in approximately 30 per cent, from 30 to 49 in approximately 15 per cent, and 50 degrees or more in approximately 5 per cent of the cases, respectively. Allen and Welch[1] found that "the percentage of cases with free acid in the stomach is just as high with 'ulcer-cancer' as it is with benign ulcer."

There are other factors responsible for the patient not being given the benefit of surgical removal of a chronic gastric lesion at an early stage, among which is the opinion of some internists that the risk of removal of a gastric ulcer is greater than the possibility of the lesion being malignant. With this

I wish to take definite issue, for the risk associated with removal of gastric ulcer should not exceed a maximum of 5 per cent, and it is possible to operate upon a large series of patients who have gastric ulcer and achieve a mortality rate of considerably less than 5 per cent. In point of fact, partial gastrectomy was performed at the clinic in 89 cases in 1939,[13] with a mortality rate of 2.2 per cent, and in 88 cases in 1940,[6] with but one death. In addition, excision of the ulcer, gastro-enterostomy, or both procedures were performed in 17 cases of gastric ulcer, with no deaths. Operation was performed in 64 per cent of cases of gastric ulcer observed in 1939, and in 61 per cent of the cases observed in 1940.*

In cases in which operation was performed for gastric ulcer, patients were selected carefully: many underwent a period of observation and a therapeutic trial of nonsurgical treatment in the hospital, and some were allowed to return home for two or three months during which time an ambulatory regimen was carried out. At the end of such a period, reexamination was carried out. Partial gastrectomy was performed only when the nature of the lesion and the condition of the patient warranted this procedure. From the standpoint of the possibility of recurrence of ulceration, I have never seen a benign gastric ulcer recur or a gastrojejunal ulcer develop after partial gastrectomy when half or more of the stomach (which includes the ulcer) was removed. This has not always been the case, however, when the gastric ulcer was excised and gastro-enterostomy performed. On the other hand, in the nonsurgical methods of treatment, recurrence takes place in a definite percentage of cases.

Another argument sometimes used in a persuasive fashion is that when the lesion is situated high on the lesser curvature, according to the roentgenologic examination, not only a course of medical therapy but a continuation of medical therapy is indicated because of the relative inaccessibility to surgical removal and hence the increased surgical risk.

In a paper dealing with cardial gastric ulcers, Cleveland and I[17, 20] emphasized that in several cases gastric ulcers which appeared, on roentgenologic examination, to be situated very high on the lesser curvature were really not as inaccessible as they seemed to be, for, at operation, it was found that the perforation of the lesion into the capsule of the pancreas had so shortened the stomach remaining above the lesion as to give an erroneous idea of the amount of stomach between the ulcer and the esophagus. In these cases there was actually more uninvolved stomach than the roentgenograms indicated. The early division of the gastrohepatic omentum at a very high level assists in mobilizing the upper part of the stomach so that unusually high lesions could be removed without too great difficulty, especially when the original method of Billroth or the Hofmeister modifications of the Pólya operation are employed, and when one removes a greater portion of the lesser curvature (containing the ulcer) than of the body or greater curvature.

* This percentage of patients operated upon for gastric ulcer should be compared with 18 per cent of patients with duodenal ulcer who were operated upon in 1939, and 15 per cent operated upon in 1940.

To confirm the impression that although removal of gastric ulcer is made more difficult when the lesion is situated above the incisura angularis but the mortality rate from the operation is not increased appreciably, Cleveland and I[17, 20] studied 42 consecutive cases in which operation for a benign lesion situated in the cardial region of the stomach was performed at the clinic in 1938 and 1939. The mortality rate in these cases was 2.3 per cent. Thirty-five of the patients had benign ulcers in the cardial portion of the stomach. In 26 of the cases, partial gastrectomy was performed, with one death, a mortality rate of 3.8 per cent. In four cases, the ulcer was excised and gastro-enterostomy performed. In one case, excision of the ulcer alone was undertaken, and in four cases, gastro-enterostomy was performed. In the nine cases, in which surgical procedures other than partial gastrectomy were employed, there were no deaths. The relative incidence of lesions in the cardial portion of the stomach in these two years was 14 per cent in the 542 cases in which operation was performed for lesions of the stomach. These included both cases of benign and malignant lesions.

Finsterer[5] and Rieder[14] both reported with favor on high gastric resection and removal of the ulcer whenever possible, and both advised the Kelling-Madlener type of subtotal gastrectomy, which allows the ulcer to remain *in situ* when it is situated too high to be removed with safety. They postulated that, by removal of the greatest acid-forming portion of the stomach, more permanent cure is effected. In this procedure, which was originally proposed by Kelling[8] in 1918, and was described and brought into favor by Madlener[11] in 1923 and 1929, resection of the stomach below the site of the ulcer is accomplished by anastomosis of the stomach to the duodenum by the Billroth I-type of procedure. Finsterer[5] has reported anastomosis of the end of the stomach to the side of the jejunum, posterior to the colon, in the palliative resection when fixation of the duodenum might cause tension on the suture line. Lewisohn[10] said that he did not favor the Madlener procedure, as the postoperative results of Madlener's operation in a large number of cases are unsatisfactory; the ulcer is not put at rest and gastric acidity is seldom sufficiently high preoperatively to require gastric resection for its reduction.

I have found the procedure of choice to be subtotal gastrectomy, in which the incision is carried well beyond the lesion, which is removed. The advantages of this procedure are as follows: (1) Removal of the lesion with its possibilities of hemorrhage, perforation or malignant degeneration; (2) relief of associated pylorospasm; and (3) decrease in the quantity of and concentration of hydrochloric acid secreted and stimulated, which results in an almost constant incidence of relative achlorhydria, with almost total absence of gastrojejunal ulceration. The Pólya-type of end-to-side anastomosis posterior to the colon, without entero-anastomosis, is, in my opinion, preferable to anterior anastomosis.

The Billroth I (Haberer) method of direct anastomosis as modified by Horsley and Haberer is occasionally employed in selected cases and is an excellent procedure in certain cases of gastric ulcer and carcinoma. It is par-

ticularly useful in instances in which the duodenum is mobile and the lesion is in the lower third or half of the stomach, for, under these circumstances, the end-to-end anastomosis can be made without tension on the suture line. It was noted by Clagett and me,[19] in a study of *272* consecutive operations for gastric ulcer performed at the clinic, from January 1, 1933 to January 1, 1937, that this procedure was employed *22* times in contrast to the posterior Pólya operation, which was employed 131 times. It should be emphasized that the results of the Billroth I procedure for gastric ulcer are satisfactory in a much higher percentage of cases than are operations of a similar type for duodenal ulcer. This is probably due in part to the fact that the Billroth I operation produces a relatively higher incidence of postoperative achlorhydria in cases of gastric ulcer than it does in cases of duodenal ulcer.

When the condition of the patient is such that removal of the lesion as a part of subtotal gastrectomy cannot be undertaken without too great risk, then as safe a procedure as possible should be utilized which sufficiently reduces gastric acidity and reduces gastrospasm so that healing of ulceration may be anticipated. Surprisingly good results may be obtained by less radical methods, such as excision of the ulcer with gastro-enterostomy or occasionally by only excision of the ulcer. Protection against further ulceration is accomplished by reduction of gastric acidity by the gastro-enterostomy. This was done 50 times with very good results in the series of cases studied by Clagett and me. Eusterman and Balfour[3] showed that 79 per cent of 100 patients upon whom gastro-enterostomy had been performed for gastric ulcer were well after five years. This procedure, which carries a low risk (a mortality rate of 3.9 per cent in 540 cases, according to Eusterman and Balfour), is thus worthy of consideration when conditions make excision or resection impossible. The palliative resection of Madlener, in which the ulcer is also left behind, has not been utilized at the clinic.

Excision with knife or cautery may occasionally be done without gastro-enterostomy but it is not recommended because it does not offer an alteration in gastric function to prevent recurrence.* In the occasional case it has been utilized with good results. It does enable microscopic study of the lesion. Similarly, segmental or sleeve resection may be done to remove the lesion, but disturbance in gastric peristalsis may follow in its wake even to the extent of the development of an hourglass deformity owing to contracture at the site of the anastomosis. In addition, little change in gastric function results, and recurrent ulceration may occur. It has been used with some success in selected cases, however, but not in recent years.

It is to be repeatedly emphasized that, when possible, removal of the lesion in some manner should be done to enable microscopic examination of the lesion. If an excision of the ulcer is done and the lesion should prove, on microscopic examination, to be malignant, its removal by partial gastrectomy gives the patient the best chance of cure, for partial gastrectomy not only removes the lower portion of the stomach beyond the point where direct ex-

* Reduction of gastric acidity and relief of pylorospasm.

tension occurs (duodenal side of the pylorus) but it removes the lymphatic region in the adjacent gastrocolic and gastrohepatic omentums, which might harbor malignant cells extending from the primary lesion. No one, by choice, desires to leave behind a gastric ulcer with the menace of malignancy in it, but, if survival of the patient is deemed impossible with its removal, some less satisfactory procedure must be undertaken.

SUMMARY

The treatment of gastric ulcers should depend on the pathologic nature of the lesion, remembering that a definite incidence, 10 to 20 per cent, of carcinomatous ulcers cannot be distinguished roentgenographically from benign gastric ulcers, and that there is not a definite symptom complex pathognomonic of benign ulceration of the stomach, for in one-third of the cases in which operation was performed for gastric carcinoma the patients had ulcer-like histories and four-fifths of these patients obtained temporary relief of symptoms when placed on a nonsurgical medical regimen. Experience has shown that a therapeutic trial of medical treatment during which the ulcer seems to disappear roentgenographically, symptoms subside, and blood disappears from the stools, cannot be relied on either to exclude the possibility of the lesion being malignant or as an indication that recurrence of the benign ulceration will not take place when the patient returns to his usual habits and activities of life.

In the past few years operation has been performed in approximately 60 to 64 per cent of the cases of gastric ulcer observed at the clinic, and the mortality rates have not been greater, and sometimes have been less, than for operations of similar type performed for duodenal ulcer. During the same period, the incidence of patients operated upon for duodenal ulcer varied from 15 to 18 per cent. The results of surgical treatment of benign gastric ulceration when subtotal gastrectomy is performed are well-nigh perfect—superior to similar operations for duodenal ulcer. To date, I have not seen a case of recurrent benign ulceration in which half or more of the stomach was removed with the benign gastric ulcer.

Efforts should be directed to determine accurately the percentage of patients with benign gastric ulcers who have remained well without recurrence after a course of nonsurgical treatment.

Although subtotal gastric resection is the operation of choice and should be employed preferably in all cases of gastric ulcer, there is a place for the less radical procedure of excision of the ulcer and gastro-enterostomy or gastro-enterostomy alone. Ulceration has recurred rarely in some cases in which excision and gastro-enterostomy have been performed but more frequently when excision of the ulcer only was performed.

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GASTRIC RESECTION FOR DUODENAL ULCER *

FOLLOW-UP STUDIES

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AND

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AMERICAN SURGEONS have approached the problems of radical operative procedures for duodenal ulcer in a cautious manner. This is the natural attitude since only a small percentage of all patients with duodenal ulcer fail to respond to the conservative measures carried out by our medical colleagues. Actually, it appears that a large percentage of the satisfactory results from gastrojejunostomy or pyloroplasty were in those patients who might have avoided surgery entirely. Since there are so few individuals who cannot be adequately treated medically, it has taken some years to realize that in this small group of patients with intractable ulcer, palliative operations are associated with a high percentage of failures.

It is difficult to take the attitude concerning the stomach that we have long since accepted for hyperactive endocrine glands. Since, as yet, we have not been successful in finding a more satisfactory solution to the problem of many types of pathologic physiology, it remains necessary, at the moment, to relieve these conditions by radical surgery. In the case of duodenal ulcer, we are dealing with a poorly understood disarrangement of normal physiology. Hyperacidity, tissue susceptibility, psychologic disorders and various other factors of temperament, environment, and economics play a rôle. Doubtless, in some instances, the location of the ulcer makes it unlike the majority of such cases in regard to nature's ability to heal the lesion, and, if healed under ideal conditions, it is prone to recur, even in spite of adequate guidance by the physician and cooperation on the part of the patient. Thus, we have the problem of protecting such individuals from repeated or continuous disability, from episodes of massive hemorrhage and from repeated perforation. This group, as a whole, comprises approximately 20 per cent of all duodenal ulcer patients coming to a large urban hospital. Of these, about one-fourth are operated upon for acute perforation and this complication will not be discussed in this presentation. Of the remaining 15 per cent, more than one-third are subjected to surgery because of cicatricial obstruction due to ulcer of long standing. The remaining cases, representing less than 10 per cent of all duodenal ulcers, are turned over to the surgeon because of massive hemorrhage or intractability. It is with these last two groups that we particularly wish to deal in this paper, since they are almost as resistant to palliative operations as they are to medical therapy.

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Gradually, there has come about a more radical attitude regarding the kind of surgery indicated in this small group of recalcitrant cases. Many European surgeons have advocated resection of one-half or more of the distal stomach for duodenal ulcer for 20 or more years. In America, there has been a hesitancy to adopt these radical principles although some men, notably Berg[1] and Lewisohn,[2] advocated and practiced these methods several years ago. It was necessary first to improve surgical principles to such a degree that the mortality for a radical operation would not be sufficiently high to offset the better results that might be obtained. Perhaps more importance was placed on the actual accumulation of experience to demonstrate that the mortality could be low and the late results better than those following less radical measures. It was hard for us to forget that approximately 80 per cent of duodenal ulcer patients were relieved by palliative surgery in the days when such a procedure was the accepted treatment. Finally, we realized that in this large group of patients responding to short-circuit operations, there were many who would have done very well on a medical regimen. Eliminating the usual type of ulcer patient, we are presented with an entirely different problem and it is these unyielding cases that we must consider in a different light than the majority.

The first question which we must strive to settle concerns the results that may be expected from these radical operations. Most of the reports dealing with the subject are concerned only with the immediate operative mortality and the various modifications of the technic of the procedure. Walters and Cleveland;[3] St. John, Harvey, Gius and Goodman;[4] and Roscoe Graham[5] have made preliminary studies of late results. It is our intention to add our experience in this field, realizing fully that our cases are few in number and not of sufficient duration to consider them as end-results. It is obvious, however, that the trend of operation for duodenal ulcer in our hospital has definitely changed during the past ten years, so that now very few cases are operated upon by palliative methods. Doubtless, this is due to the fact that these less radical procedures are associated with a very high percentage of poor results. On the other hand, every patient who has had a radical resection of the distal half or more of the stomach and pylorus has been free of symptoms and none has as yet developed recurrent or anastomotic ulcers.

Analysis of 67 cases of jejunal (anastomotic) ulcers in our clinic indicates that one-third originate within the first year and two-thirds within the second year after the primary operation. Occasionally, this complication develops later and, in fact, two of our patients developed jejunal ulcers 18 years after their operation for duodenal ulcer. During the past ten years, 16 jejunal ulcers have been admitted following posterior gastro-enterostomy previously performed in this hospital; 22 others were admitted during the same period, who had had the gastro-enterostomy performed elsewhere. Since 137 patients survived posterior gastro-enterostomy in this decade, the incidence of jejunal ulcer is well over 10 per cent. This complication of stomal ulcer is by far the most serious that occurs, but there are other evidences of patients being

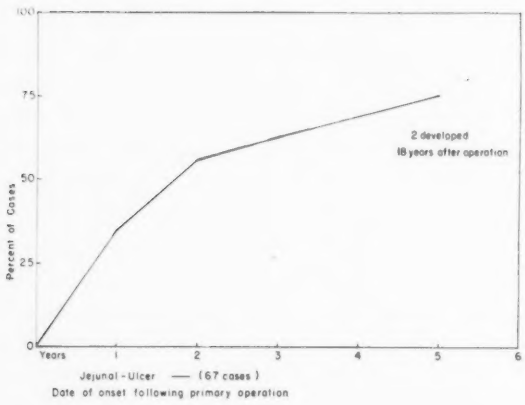

CHART I.

unrelieved of symptoms or even in a worse state than existed prior to operation. Accepting the fact, then, that the poor results are so common in those having simple posterior gastro-enterostomy in this decade that we can eliminate this group from further discussion, we will concentrate on the results, so far known, from other types of operation.

TABLE I

DUODENAL ULCERS

Massachusetts General Hospital

ULCERS INTRACTABLE BECAUSE OF PAIN OR BLEEDING

	Type of Operation		
	P.G.E.	Resection	Other Operations
1922–1926	87	6	14
1927–1931	37	8	6
1932–1936	20	39	7
1937–1940 (4 years)	8	65	5

It has gradually become obvious to us that the type of surgery most likely to succeed is gastric resection. The manner in which this has been performed and the amount of stomach sacrificed has varied somewhat. We have been influenced by the opinions of European surgeons as well as by our more radical American colleagues. There has now come about a general consensus of opinion that intractable duodenal ulcer should be treated by gastric resection. The ideal situation appears to be one that allows the safe removal of not less than one-half of the distal stomach and that portion of the duodenum containing the ulcer. By a process of long preparation, the majority of patients can be brought to the operating room with a lesion healed sufficiently to make such a procedure safe. Subtotal gastrectomy for duodenal ulcer is dangerous if the patient is depleted from recent hemorrhage or from partial obstruction, or has an acute lesion associated with extension of inflammation due to perforation into the pancreas and other neighboring

structures. We should be able to avoid the first two risks by adequate preparation, while in most instances the acute and subacute reactions can be allowed to subside before undertaking the operation. The chief danger in the latter group is the management of the duodenal stump. This has brought about methods of resection for exclusion of the ulcer area and without doubt these have lowered the risk in certain cases. The results, however, have not been so good and if the antral mucosa has been left, the results are as bad as if not worse than those obtained by gastro-enterostomy.

In the ideal operation, one is able to resect the pylorus and find sufficient healthy duodenum to secure an adequate inversion of the stump. We believe that this requires at least three-quarters of an inch of free duodenum. We have felt more secure with two rows of catgut sutures inverting the cut end of the duodenum so that its peritoneal coats were in contact with each other. We think that if this is done so that no mucosa protrudes between the suture lines, healing will be rapid and secure. A tab of omentum fixed over the stump is doubtless an added safeguard. If one has to be satisfied with sutures under tension, inadequate tissue of suitable healing properties or closure of the anterior wall of the duodenum to the pancreas over a remaining ulcer bed, then complications with prolonged convalescence and possible fatal outcome must be expected. With increased experience, the surgeon will find that he will be able to remove safely the diseased area in a larger percentage of cases. Dissection of the ulcer area first is not recommended since often this may be carried far enough to break up the inflammatory protection about the lesion, only to reveal the involvement of the biliary and pancreatic ducts. Having done this and then resorting to an exclusion type of resection leave the ulcer in a more likely state for perforation. We have had this experience with fatal perforation three days following a subtotal gastrectomy for acute massive hemorrhage. Reports are available of massive hemorrhage from the ulcer when treated in this manner, although, so far, it has not occurred in our cases. One can, however, look the situation over carefully and if there is reasonable hope that the ulcer area can be safely included in the resection, then the lateral border of the duodenum can be freed, as originally advocated by Finney.[6] Having done this, one may determine the course of the common bile duct and its point of entry into the duodenum. Frequently, one can be sure that the area involved in the ulcer is sufficiently proximal to this point to allow a safe removal.

If there is extensive involvement of the whole area, particularly if the lesion is fairly acute, then it is safer to elect some form of resection for exclusion. This term we owe to Finsterer,[7] who at first described it as any resection proximal to the ulcer whether the distal segment included the pylorus or not. He found, after his first publication, that several other surgeons had tried similar procedures. In his first paper on the subject, he advised removal of the antral mucosa and turning in only the muscular and serous coats when this segment was utilized. When the duodenum was turned in

with the ulcer *in situ*, he later advised routine drainage of the area. In subsequent publications,[8] he not only advised leaving the antral mucosa but felt that these cells were important to a good result. He stressed a massive resection of two-thirds to four-fifths of the stomach and attributed his lack of late jejunal ulcer to the large amount of stomach removed. We have, perhaps erroneously, not considered the resections beyond the pylorus but proximal to the ulcer as resections for exclusion, and have grouped them in the same category as true subtotal resections. The results in this small group would appear to be as good as a resection including the ulcer, but the postoperative complications were more numerous and the mortality was higher. This was due largely, we are sure, to the inadequate management of the duodenal stump. We have included as resections for exclusion only those cases that have been transected through the antrum. In this group, we have ten cases that did not have the antral mucosa removed, and five of the nine survivors developed anastomotic jejunal ulcers. The other four are so far symptomless, and we are sure that these did not have a more radical resection than those who developed jejunal ulcers. We have removed the mucosa in the antral segment in 13 resections for exclusion and have erroneously called this Bancroft's modification. We are indebted to Bancroft[9] for the idea after his report on such a maneuver for the modification of the Devine operation. In these cases with a resection of more than half of the stomach, leaving the antrum but removing its mucosa, we have had one death in 13 cases. In those who survived the operation, there has been no single instance of anastomotic jejunal ulcer so far. Although this would indicate that the mucosa contained the elements needed to produce hyperacidity in the proximal stomach remnant, the group is so small that one can only use it for comparison with the other small group that did not have these cells eliminated. We regard this procedure as definitely second best on the basis of considerable increase in postoperative complications over those who could safely have the resection carried into healthy duodenum. Complications arose due to the thin, friable structure of the posterior wall of the antrum after removal of its mucosa. One must exercise care in the denudation and carefully infold the remaining tissues to close the dead space adequately. We have found it best not to ligate the mucosa at the pylorus but leave it open since this enhances the discharge of serum into the duodenum.

McKittrick[10] has suggested a deliberate two-stage resection in poor risks and in patients who had extensive ulceration or inflammatory reaction. The relative smoothness of the immediate convalescence following resection for exclusion without interference with the ulcer or antral mucosa is apparent to those who have used it. Also, the ease with which this segment can be removed after weeks of physiologic rest is impressive. Doubtless, an occasional patient so treated will develop jejunal ulcer before the second stage can safely be undertaken. On the other hand, the majority of cases so treated will survive the two procedures and rarely will jejunal ulcer arise in the six to eight weeks' interval between them. In one instance, McKittrick

has observed the healing of a jejunal ulcer after the simple removal of the pyloric segment. This patient had had three operations in other hospitals before coming to us. The last resection had left him with a very small proximal stomach segment but a very painful disabling anastomotic ulcer. Although it had been reported that he had had a true subtotal resection, on exploration it was found that a small antral segment had not been removed. The jejunal ulcer pain was immediately relieved after this pyloric segment was eliminated.

We have reoperated upon one man twice for jejunal ulcer after the first resection for exclusion without removal of the antral mucosa. The second operation, six months after the original, consisted of a higher resection of the stomach and the segment of jejunum containing the stoma and its ulcer. Less than two years later, anastomotic ulcer developed in spite of great care on the part of the patient. By this time, we were aware of the danger of the antral cells so that at the third operation the pyloric segment was removed as well as the second anastomosis with its ulcer. Although this man was nearly 70 years of age and somewhat arteriosclerotic, he had an easier convalescence following the third procedure than either of the other two. He has remained entirely symptom-free now 24 months after his last operation. We are convinced that the higher resection played a lesser rôle in the cure of these patients than did the elimination of their antral segment.

TABLE II

DUODENAL ULCER

Massachusetts General Hospital

MORTALITY (1931–1940)

	486 Operations	Died	Per Cent Mortality
Acute perforation	165	44	26.6
P.G.E.	151	14	9.3
Resection	151	14*	9.3
Other operations	19	2	10.3

* Seven patients died after operation for massive hemorrhage.

TABLE III

DUODENAL ULCER

Massachusetts General Hospital

MORTALITY ACCORDING TO TYPE OF OPERATION (1931–1940)

	Cases	Deaths	Per Cent
Resections			
Subtotal	56	3	5.4
Partial (Pólya or Billroth-II)	42	6	14.3
Billroth-I	4	0	
Pylorectomy	26	3	11.5
Finsterer exclusion (through antrum)	10	1	10.0
Finsterer exclusion (plus removal of antral mucosa)	13	1	7.7
Gastrojejunostomy	151	14	9.3
Gastroduodenostomy	8	1	12.5
Pyloroplasty	10	1	10.0
Devine operation	1	0	

In Tables II and III, it is apparent that, in our hospital, gastric resection does not carry a higher mortality rate than less extensive operations. We have classified those patients having more than the distal half of their stomachs, including the pylorus, removed, as subtotal resections. Those that had a quarter to a half removed are designated as having partial gastrectomy, and those who had the pylorus only removed with gastrojejunal anastomosis as pylorectomies. The Billroth-I operation was rarely performed and was probably not more than a pylorectomy. We have described in the foregoing paragraphs our classification of the two resections for exclusion practiced in our institution. Simple posterior gastro-enterostomy carried the same mortality as all of the resections. In the former group, one may immediately expect that these were in the older, poorer risk patients, but this is not the case. In the latter group, we have included seven failures from resection during an episode of massive hemorrhage. All but two of these failures were in attempts to rescue a patient who had been bleeding for over a week. The recovery group includes six cases, all beyond the age of 50, who were operated upon within 72 hours of the onset of bleeding.

TABLE IV

DUODENAL ULCER

Massachusetts General Hospital

COMPLICATIONS FOLLOWING 151 GASTRIC RESECTIONS (1931–1940)

	Fatal	Nonfatal
Peritonitis	4	1
Pulmonary	3	13
Duodenal fistula	1	3
Section of common duct (bile peritonitis)	2	1
Hemorrhage	4	1
Obstruction	0	8
Miscellaneous	0	9

In Table IV, we have analyzed the complications following gastric resection for duodenal ulcer and grouped them as fatal or nonfatal. Those dying of peritonitis were due to the ulcer harboring virulent organisms. By preliminary culture of the stomach contents, and by the use of sulfonamides, one might hope to eliminate these deaths. Fatal pulmonary complications are much less common than in previous decades and when they occur, are usually in aged, debilitated patients. Duodenal fistula should be a rare complication if one uses the proper operation for each case. It is important to recognize leakage when it starts and immediately establish external suction drainage. One might occasionally benefit by drainage at the time of operation, using extreme care to avoid contact of the wick with the sutured duodenum. We were shocked to find that there were two common ducts injured during gastric resection for duodenal ulcer, with fatal bile peritonitis. Both of these were patients of the same operator. The nonfatal injury to the duct was recognized and repaired at the time of operation. This not only complicated the convalescence but the patient still has symptoms from a poorly functioning choledocho-enterostomy. Hemorrhage after resection should be

rare. One fatal instance was in a patient with a peculiar hemorrhagic diathesis. On reexploration, blood was found to be coming from every cut surface, including his abdominal wall. Although it was before synthetic vitamin K was available, his prothrombin level was determined immediately after operation and found to be 20 per cent of normal. It is interesting to note that postoperative hemorrhage may occur in patients of a normal prothrombin level, and we have had two similar episodes in other types of surgery. One woman following radical breast amputation and one man following subtotal thyroidectomy bled in the same manner. These both had normal prothrombin times and finally escaped bleeding to death after several transfusions.

Obstruction of the stoma,[11] although annoying, should rarely prove fatal. In depleted patients or those whose anatomic variations make early function of the stoma unlikely, a concomitant jejunostomy for feeding is a wise precaution (Clute[12]). Stomal obstruction should not be allowed to progress longer than one week on conservative management. Jejunostomy for feeding, undertaken in a logical manner before it is too late, will invariably allow the stoma to right itself, provided the first operation has been properly performed.

TABLE V

DUODENAL ULCERS

Massachusetts General Hospital

RESULTS ACCORDING TO TYPE OF OPERATION (1931–1938)

	Excellent	Good	Poor	Operative Deaths	Lost
Resections:					
Subtotal	6	1		1	1
Partial	29	5	2	7	9
Pylorectomy	5	2	3	2	2
Finsterer exclusion (through antrum)	4		5	1	
Finsterer exclusion (plus removal of antral mucosa)	1				
Billroth-I	1		1		1
Gastroduodenostomy	2		2	1	2
Pyloroplasty	1		3	1	5
Totals	49	8	16	13	20

The results on a small group of cases, followed from three to nine years, are classified in Table V. An excellent result signifies that the patient has remained symptom-free since operation, and able to do his regular work. Thirty-five of 43 patients (81 per cent) who had partial or subtotal resections are classified in this group. Although all of these patients are cautioned about the use of highly seasoned foods, alcohol, and tobacco, many of them gradually discard all precaution in this regard.

Good results signify a situation that, although not perfect, allows a patient to carry on his usual occupation but with some occasional discomfort, such as nausea after eating or epigastric distress and sour eructations. One patient has an annoying gastrocolic reflex, without evidence of jejunal ulcer or gastrojejunocolic fistula. Another patient had a single episode of massive bleeding five years after the distal half of his stomach and pylorus was re-

sected, with a posterior Pólya anastomosis. The origin of the hemorrhage was proven by gastroscopy to be due to gastritis. This cleared up on conservative measures. Doubtless, this patient had become too confident regarding the operative cure and had abused his gastric mucosa unwisely.

The poor results represent nine proven and two suspected jejunal ulcers. One patient continued to have periodic hemorrhage and another had persistent pain. Three of the jejunal ulcers following the Finsterer exclusion operation have since been reoperated upon and relieved. The high incidence of stomal ulcer after the exclusion operation, without excision of antral mucous membrane, has also been emphasized by Fromme[13] and Haberer.[14] One failure following pyloroplasty and one following gastroduodenostomy, with subsequent massive hemorrhages, should be reoperated upon. One patient who developed anastomotic ulcer eight months following a Billroth-I operation was subjected to subtotal gastrectomy with relief. Two jejunal ulcers followed pylorectomy with Billroth-II anastomosis—one after 18 months and the other after two years; both should be reoperated upon.

Only one jejunal ulcer has so far developed following partial resection and that came three years after the first operation. This man had about a quarter of his stomach removed. It is our belief that he has antral hormone cells remaining in his proximal segment, and this is some argument in favor of removing at least the distal half of the stomach.

The other poor result followed a partial resection of the Pólya type. The patient was entirely relieved for four years, but since then has had several massive hemorrhages. He has recently entered another hospital for further treatment.

TABLE VI

DUODENAL ULCERS

Massachusetts General Hospital

RESULTS (1938–1941)

Subtotal resections	76
Deaths	5
Present Status:	
Poor in one case (postoperative common duct stricture)	
Excellent in all others	
Six to 12 months are required to regain appetite and weight.	

During the 34 months not included in the follow-up table, we have had 76 subtotal gastrectomies for duodenal ulcer with five deaths. None of the survivors has been invalided since, save the man whose common duct was sectioned and reanastomosed to the duodenum. He had signs of cholangitis, and may continue to have disability from this complication although a cholecystojejunostomy has been performed recently. It is interesting to note that some patients are able to return to work in three months, although it takes from six to 12 months for these individuals to get so they can get along

on three full meals a day and gain weight. There is also a lag-period as regards appetite. This, we believe, is due to the interference with the nerve supply to the remaining proximal segment. It is amazing, however, to see these people eat a large meal and enjoy it without distress after they have become adjusted to their new arrangement. So frequently these individuals want to know why surgery has been withheld from them so long. Little do they realize what a stormy convalescence some of the survivors have had.

SUMMARY AND CONCLUSIONS

(1) Cases of duodenal ulcer now requiring surgical treatment represent about 20 per cent of all patients with this lesion coming to a large urban hospital.

(2) Acute perforation accounts for about one-fourth of these operative cases.

(3) Cicatricial obstruction from duodenal ulcer, usually of long standing, is the indication for operation in one-third of the remaining cases.

(4) Intractability and massive hemorrhage make surgery necessary in the remaining cases and these represent less than 10 per cent of all duodenal ulcer patients.

(5) In this last group, palliative operations such as gastro-enterostomy, pyloroplasty, gastroduodenostomy, local excision (even with the pylorus), transection for exclusion, and gastric resection for exclusion, without removal of the antral mucosa, are all attended with a high percentage of persistent symptoms and anastomotic jejunal ulcer.

(6) The mortality following subtotal gastrectomy for duodenal ulcer in the Massachusetts General Hospital was not greater than that following less extensive operations.

(7) In those cases operated upon from three to nine years prior to this report, the results of true partial gastrectomy were excellent or good in all but two cases.

(8) Two-thirds of 67 jejunal ulcers following palliative procedures for duodenal ulcer occurred within two years of the original operation in our clinic.

(9) In 71 survivors of 76 subtotal resections performed during the past 34 months, no jejunal ulcer has thus far developed. This, we believe, is the procedure of choice. Certainly, not less than half the stomach together with the pylorus should be removed when feasible.

(10) In complicated, extensive ulceration, one is justified in resection for exclusion provided the antral mucosa is removed at the original procedure, or that the whole remaining distal segment is removed as a second stage six to eight weeks later.

(11) Our poorest results were in those cases with resection for exclusion without removal of the antral mucosa—five jejunal ulcers in nine operative survivors.

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DISCUSSION.—DR. FREDERIC W. BANCROFT (New York, N. Y.): I should like to report a case that is rather historic. This patient had a lesser curvature ulcer and was operated upon by me in 1930. A high subtotal gastrectomy was performed. Dr. Lewis Gregory Cole took sections from this ulcer, half from one side and half from the other, and sent the sections to a number of pathologists without giving any identification or history. On one side, all pathologists were agreed that it was benign, whereas on the other side, 75 per cent diagnosed some type of carcinoma. This patient presented himself to my office recently, after having had three severe gastric hemorrhages. Roentgenograms do not show definitely any ulcer, and gastroscopy was negative. In going into this patient's history I have learned that he has been on a very low vitamin diet, and it is possible that his hemorrhages at the present time are not due to a jejunal ulcer or to recurrence of the carcinoma.

I should like to say a word about the modified Devine operation. Recently, in order to remove more of the pyloric antrum, I have mapped out an area in the prepyloric zone which would be sufficient, after denuding the mucous membrane, to allow a triple inversion. The stomach is transected at this portion; then further stomach is removed toward the cardia in order to give sufficient excision of the stomach. I think this procedure has certain advantages. There is usually no difficulty in a duodenal ulcer in removing this portion of the stomach. I had one patient that suffered from a hemorrhage where I had left too large a cuff at the prepyloric region. Also, one

must warn against too far exploration if this procedure is decided upon, because in the only sure death I have had I explored the duodenum rather thoroughly before attempting the operation. The patient died five days later of peritonitis, and at autopsy it was found that he had perforation of the duodenal ulcer. I think I caused this perforation by too much exploration.

DR. R. L. SANDERS (Memphis, Tenn.): Doctor Allen and Doctor Walters have given us two interesting and worth while papers. My remarks will be devoted to Dr. Allen's paper, emphasizing two points: First, a definite swing from gastro-enterostomy to partial resection in the treatment of duodenal ulcer; and second, the necessity for removal of the pylorus and the ulcer.

Recently we reviewed a series of 110 surgical cases of duodenal ulcer covering the years 1925 to 1934, inclusive. It was found that gastro-enterostomy was performed in 102 of these, and resection in only eight. In a similar study of cases covering the period of 1935 to 1940, there were 29 resections as compared to 31 gastro-enterostomies, or practically an equal use of both procedures in the treatment of duodenal ulcer. Our results have justified this change in the type of operation.

Regarding the necessity for removal of the pylorus, in a follow-up of the above mentioned 29 patients who had had resections, two were found to have a poor result; in neither case had the pylorus been resected.

One of the cases of the earlier group was so unusual and so well illustrates this point that I shall report it briefly: The patient had had a gastro-enterostomy in 1918 for a nonobstructing duodenal ulcer associated with high acids. He developed a gastrojejunal ulcer and came to us for treatment. We performed a partial gastrectomy but did not remove the pylorus because of technical difficulties. Later, another gastrojejunal ulcer developed and perforated, and a second resection was carried out, the ulcer being removed with a little more of the stomach and the anastomosis reset. Still later, the cycle was repeated and resection was performed the third time. Again, an ulcer formed and perforated. By this time, which was in 1931, the patient was tired of being operated upon for ulcers, for which I could not blame him. He went elsewhere and had both adrenals denervated. His pain continued, however, and he became a morphine addict. He died two years ago, still unrelieved of his suffering. Had we removed the pylorus at the first resection the whole course probably would have been different. It is now our practice and teaching to remove, when possible, the pylorus as well as the ulcer in all stomach resections.

DR. ROBERT L. PAYNE (Norfolk, Va.): I wish to ask a question which I think is of interest to every man here who does not do as many gastric resections as the essayists. The problem which concerns me is the satisfactory closure of the duodenal stump. Doctor Walters stated that the risks involved in resection for carcinoma were less than in resection for ulcer of the duodenum because of the ease of closing satisfactorily the duodenal end of the resection. I am impressed with the fact that the danger of leakage, with peritonitis, or the development of a duodenal fistula centers around the proper and satisfactory closure of the duodenal stump. Doctor Allen reported one case of duodenal fistula with death, and stated that he had devised a means to circumvent this in the future. I would like him to explain that statement—whether he divides the duodenum above the ulcer in healthy structures, does a Finsterer exclusion, or exactly what method he has devised to overcome the danger of leakage from the duodenal stump.

Dr. Arthur W. Allen (Boston, Mass., closing): Doctor Bancroft cited the case of a jejunal ulcer coming years after subtotal gastrectomy for gastric "ulcer-cancer." This is so unusual that I wonder if, by any chance, a small segment of antrum remained. We have a patient with anastomotic ulcer following subtotal resection for acute massive bleeding from gastric ulcer and, on reviewing this case, we find that we had left a small remnant of the antrum. Jejunal ulcers are very rare following any operation for gastric ulcer.

Dr. Sanders' case report is duplicated in our paper, except that in our case the patient came back and we resected the pylorus and the second jejunal ulcer on the third operation, and he has remained well since. One man had had three resections elsewhere before he came to us. He had a jejunal ulcer that had developed very quickly after the third operation, and I suggested that we do nothing except remove the pyloric segment, which we surmised had been left at his original resection. He was relieved immediately following its removal. The stomal ulcer healed without reoperating upon the stoma, much to our surprise, and has remained healed for 15 months.

Doctor Payne's question involves a lot of time for discussion and can be answered only in a general way. One must determine the location, extent of inflammatory reaction, and the neighboring structures involved before deciding the type of operation to undertake. The ideal situation is one that allows resection beyond the ulcer, leaving at least three-quarters-inch of normal duodenum to invert. Two rows of carefully placed catgut sutures, both introduced so that peritoneal surfaces are held in contact, and so that all the mucosal edge is turned in, will ensure healing with no fear of blowing out. The reaction caused by the catgut in these healing serous surfaces may enhance adherence and seal the surfaces more securely. Silk or cotton, with their greater tendency to cut through delicate structures and their lack of reaction, may make them less useful for this purpose than one would expect. I have very rarely found sufficient normal duodenum to work with to use the ingenious instruments devised for inverting the duodenal stump.

Doctor Bancroft has brought out the danger of late perforation if one undertakes too much dissection in the region of the ulcer, and then finds that he must limit the operation to resection for exclusion. We have made the same error in one case with fatal perforation three days after operation. On occasion, one can see by the extent of the inflammatory reaction that an attempt to resect beyond this would, at least, be tedious and possibly dangerous. One can, however, free the lateral border of the duodenum as first described by Doctor Finney in his pyloroplasty operation, and determine the entrance of the common duct into the duodenum. This is harmless and often settles the question regarding the proper procedure in that particular case.

If, in order to be sure of a comfortable closure of the distal segment, one must resort to resection for exclusion, then two choices are available. One may denude the remaining antrum of its mucosa and hope to cure the patient at one operation. Due to the thinness and friability of the remaining peritoneal and muscular coats of this segment, I have sometimes been unhappy about the type of closure that could be obtained. Some of our cases have had their convalescence lengthened on this account. The remaining choice is a deliberately planned second stage, six to eight weeks later, for the removal of the antral segment. McKittrick thinks well of this two-stage operation at the moment, and may be able to demonstrate that this is not only the safest procedure in complicated cases but that the actual time involved may not be too much increased.

DR. WALTMAN WALTERS (Rochester, Minn., closing): I just want to clarify a point mentioned by Doctor Payne, namely, that the risk of resection of the stomach, or partial resection for carcinoma, is greater than for benign gastric ulcer or duodenal ulcer. The risk for resection of the stomach in cases of chronic gastric ulcer is less than in cases of duodenal ulcer. The reason for this is the difficulty of closing the duodenal stump and, because of foreshortening of the duodenum by the ulceration, the possibility of leakage of the duodenal contents.

The results of resection of the stomach for gastric ulcer are well-nigh perfect. I have never seen a case of recurring ulcer in which a subtotal gastrectomy has been performed for benign gastric ulcer. On the other hand, although I have an optimistic view of the results of the surgical treatment of duodenal ulcer following partial gastrectomy, yet I want to call attention to the fact that recurring ulceration does take place. In a group of cases of gastric resection studied by Lewis and me, it was found that recurring ulceration took place in 2 per cent of cases. In a very interesting monograph by Starlinger, he summarized the results of resection of the stomach and duodenum in 25,000 cases of duodenal ulcer and gastric ulcer operated upon in central European clinics. In that series the recurrences were 2 to 2.5 per cent. In other words, resection of the stomach for duodenal ulcer is not the complete answer to the prevention of recurring ulcer. However, the results so far suggest that one must take into account that the recurrence rate is very small, with a reasonably low mortality rate, and the results are usually excellent.

SARCOMA OF THE SMALL INTESTINE *

REPORT OF FOUR CASES

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This paper is based upon a careful study of the cases of primary sarcoma of the small intestine as reported in the past ten years, and an analysis of four cases which we wish to add to the literature. A thorough study of all publications, from 1932 to August, 1941, was made in order to learn how many cases of sarcoma of the small intestine had been recorded. There are 114 cases reported. Two of these, each published in two different journals, both foreign, are counted only once. The details of 102 cases are reported, and 12 others are mentioned, six by Medinger, three by Boyce and McFetridge, two by Sanchez, and one by O'Herne. Sufficient data are not presented in the papers of these authors for us to include them in any detailed study.

Crowther, in 1913, collected 191 cases of sarcoma of the intestine of which 117 were in the small bowel. Graves, in 1919, reviewed the literature and recorded 249 cases including three of his own. Ullman and Abehouse, in 1932, collected an additional 125 cases of intestinal sarcoma and added one. It was interesting to note that in reports by three different authors it was stated, "this is the 276 th case." We wish to call attention to the fact that the contributions of Graves and also that of Ullman and Abehouse are concerned not with sarcoma of the small intestine but of the entire intestinal tract. Ullman and Abehouse state that of their collected cases only 77 were in the small intestine, and they added one case of lymphosarcoma of the ileum. It has been impossible for us to review all of the literature previous to 1932 in order to present the exact number of cases of sarcoma of the small intestine on record. We probably have overlooked some cases reported since that date but, if so, it is due to the fact that the title of the paper was misleading.

It has been the observation of many investigators, including Corner and Fairbanks, that the incidence of the ratio of sarcoma of the small to sarcoma of the large intestine is 2:1. If we should start to figure from the report of Graves we would conclude that of his 249 cases only 166 were in the small bowel. Ullman and Abehouse add 77 cases, making a total of 243 cases on record up to 1932. We have investigated all reports since that date and have

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collected 114 cases and are adding four more, making the probable total cases of sarcoma of small intestine on record 361.

Sarcoma of the small intestine is rare. Perry and Shaw, quoted by Brill, investigated the autopsy records of Guy's Hospital from 1826 to 1893, and found only six cases of sarcoma of the small intestine in 17,652 necropsies. Libman states that there were no cases observed in the Berlin Pathological Institute from 1859 to 1875, and Nothnagel reported only nine in 21,358 autopsies in the General Hospital of Vienna from 1882 to 1893. In the Prague Pathological Institute, from 1883 to 1898, Smoler found 13 cases in 13,036 postmortem records. In the New England Deaconess and Palmer Memorial Hospitals, from 1927 to 1939, Medinger was able to find ten malignant tumors of the small intestine at autopsy, and in the surgical material studied there were 12 instances. In other words, in 42,456 examinations he found 22 cases of malignancy of the small intestine and of these only six were sarcomata. Chont in a review of 2,252 necropsies and 20,603 surgical specimens from the University of Oklahoma Hospital found only eight tumors of the small intestine including four sarcomata.

Sarcoma of the small intestine occurs more frequently in males. Chont places the ratio of males to females as 3:2. In the cases we reviewed there were 75 males and 27 females, a ratio of practically 3:1. This is in accord with the findings of Speese and Graves (Table I).

TABLE I

SARCOMA OF THE SMALL INTESTINE

1932–1941

Cases available for study	102
Males	75
Females	27

Ratio: Males to Females 3 : 1

The disease is more common in the middle-aged. Relatively few cases were observed in individuals under age 30. Our findings agree with those of Cameron who states that infants and children comprise 10 per cent of the cases of sarcoma of the small bowel. From our studies it is evident that 50 per cent of the cases of small intestinal sarcoma occur between the ages of 30 and 60. The average age of males was 41+ and of females 43+ years (Table II).

TABLE II

SARCOMA OF THE SMALL INTESTINE: AGE INCIDENCE

1–10	13
10–20	1
20–30	9
30–40	19
40–50	16
50–60	26
60–70	13
70+	5

Average Age: Males 41 +, Females 43 +

Trauma is thought to be a causative agent of small intestinal sarcoma. Boyce and McFetridge mention this as an etiologic factor. Ullman and Abehouse are also of the opinion that trauma plays an important rôle in the pro-

duction of the disease and state that it occurs more frequently in the working class. Zwalenburg records a case occurring in a child six weeks after injury. Peterson writes of three patients who developed intestinal sarcomata six to ten weeks after abdominal contusion, and Vercellotti agrees that trauma is a most important factor in the production of sarcoma of these structures. We could obtain no history of abdominal injury in our cases although three of them occurred in individuals of the working class.

Symptoms.—The onset of symptoms may be sudden, due to perforation, severe hemorrhage, or acute intestinal obstruction. Usually, however, the disease is insidious in onset and is characterized by griping pains in the abdomen and occasional attacks of nausea and vomiting, loss of weight and strength, and anemia. Frequently there is change of bowel habit, with attacks of diarrhea. If the disease is widely disseminated there may be some elevation of temperature.

The symptomatology varies depending upon the site of the lesion. When the duodenum is involved vomiting and jaundice may be early symptoms, simulating gallbladder disease. When the tumor is located in the lower jejunum or ileum the first symptom may be the appearance of a mass in the abdomen; for instance, Case 3 of our series was referred with a diagnosis of appendiceal abscess. He had abdominal pain, vomiting, some fever, and a mass in the lower right abdomen.

Not infrequently acute intestinal obstruction causes the patient to consult a physician. Obstruction is rarely due to the growth itself although the tumor may be the cause of intussusception. The obstruction frequently is due to kinking and, consequently, the formation of adhesions between adjacent loops of small bowel. Also, when the tumor grows it extends along the submucosa infiltrating it and the other layers of the bowel, and as a result we get the formation of a rigid tube of varying length in which no peristalsis occurs and obstruction supervenes. Other causes of intestinal obstruction due to sarcomata are compression of, or, encroachment on, the lumen, and frequently the presence of small or large annular masses. Cameron states that the annular constricting type of sarcoma of the small intestine is much more frequent than that type characterized by an aneurysmal dilatation of the intestine.

Chemical examination of the stool usually reveals the presence of blood. Occasionally, the first evidence of the disease is a massive hemorrhage, such as occurred in our Case 2, and in the case reported by Mahaffey.

Perforation is rare. Chont was able to collect from the literature only seven cases of intestinal perforation due to sarcoma. Case 1 of our series was operated upon for an acute intestinal perforation. In addition to those enumerated by Chont (Hulbert, Pissarewa, Premoli, Whitaker and Fischer, Oettle, Davis, and Lewis), we also found reports by Leveuf and Godard, and by Goldsmith, in which perforation was followed by a localized abscess. Other perforations are reported by Frankman and Drummond, Monad and Arnal, Mumey, and Basabe.

The diagnosis of small intestinal sarcoma is made on the history of abdomi-

nal pain, blood in the stools, some loss of weight, and the presence of an abdominal tumor. The location of the tumor varies. It may be palpable one day and not the next. This is because the weight of a growth in the jejunum or ileum would naturally predispose to its location within the pelvis and it would be evident only when distention of other intestinal loops force it out of the pelvis. In one of our patients the tumor was palpable on one occasion and at a later examination could not be felt at all.

Most of the cases of small intestinal sarcoma are not diagnosed previous to operation. The earlier writers decried the value of roentgenologic studies in these cases; however, within recent years roentgenologic examination of the small intestine has become valuable. Medinger states that such studies are of value in 50 per cent of cases, and Cameron emphasizes the importance of such studies. It has only been within the past few years that roentgenologists and clinicians have realized that much information can be gained by roentgenologic study of the small bowel. Cohn, Landy and Richter urge that this be done in all cases presenting intestinal symptoms.

Roentgenologic Diagnosis of New Growths of the Small Intestine.—The roentgenologic diagnosis of new growths of the small bowel may be divided into two groups: (1) Those causing a high degree of obstruction at the site of involvement; and (2) those in which obstruction is not a factor of importance.

The site of those lesions which cause a high degree of obstruction may be demonstrated at times by so-called preliminary or plain films of the abdomen made with the patient horizontal and upright. In such cases distended loops of the small bowel may be seen and the approximate site of obstruction indicated by their appearance and by the point at which the column of gas ends. The mucosal folds of various parts of the small bowel differ quite markedly in appearance, and this characteristic is of aid in localizing the growth. Obstructive lesions may demand further investigation. Some have been demonstrated by giving a small amount of barium by mouth, then tracing the column downward to the point of obstruction. This method is now seldom used and can be dangerous. The safest procedure is to pass a Miller-Abbott tube into the small intestine and to trace its progress downward, decompressing the bowel en route, until the progress is arrested. The lesion itself then can frequently be outlined by injecting opaque material through the tube.

In nonobstructing new growths the only satisfactory method of demonstration is the so-called "small bowel study." In this method from 90 to 180 cc. of an aqueous suspension of barium sulphate is given by mouth and the progress of this material through the small intestine is observed at frequent intervals, the interval between observations varying with the condition found in each case.

When a new growth in the duodenum is a consideration, serial films of the entire duodenal area are essential, inasmuch as early lesions may manifest themselves only by distortion or obliteration of the mucosal folds in the affected areas. In the jejunum and ileum, in addition to the conventional films, those

made with localized pressure over portions of the bowel that seem to be abnormal may be of great benefit in arriving at a definite diagnosis.

Nonobstructing new growths of the small intestine manifest themselves by deformity of the lumen, obilteration of the mucosal folds, or by evidence of mild interference with the progress of the column where an appreciable degree of obstruction is not present.

Pathologic Types of Lesions.—In 102 cases that we studied the pathologic type of the growth was stated. There were 66 lymphosarcomata, and three reticulum cell sarcomata. These are both of lymphoid origin, hence it may be said that more than 50 per cent of cases of small intestinal sarcomata are of the lymphoid type. Twenty-three cases were thought to originate in the musculature and are listed as 22 leiomyosarcoma and one myosarcoma. Ten cases are listed as follows: Fibrosarcoma six, neurofibrosarcoma three (two of which were reported by the authors) and one spindle cell sarcoma. It is exceedingly difficult to say with any certainty whether a growth is a leiomyosarcoma or a neurofibrosarcoma. The very best pathologists disagree as to the exact classification of these tumors but all agree that they are sarcomata; in other words many reported as leiomyosarcoma may be fibro- or spindle cell sarcoma (Table III).

TABLE III

SARCOMA OF THE SMALL INTESTINE: HISTOLOGIC TYPES

Lympho-	66	69
Reticulum cell	3	
Leiomyo-	22	23
Myo-	1	
Fibro-	6	10
Neurofibro-	3	
Spindle cell	1	
Total	102	

Location of the Lesion.—In the series under discussion the lesion appeared in the duodenum 21 times, in the jejunum 26, and in the ileum 41 times. In one case the exact location of the lesion was not stated. There were two instances in which Meckel's diverticulum was the site of the primary growth. Sarcoma, in contradistinction to carcinoma, not infrequently appears as multiple lesions and may even occur in all parts of the intestine (Table IV).

TABLE IV

SARCOMA OF THE SMALL INTESTINE: LOCATION

Duodenum	21
Jejunum	26
Ileum	41
Not stated	1
Jejunum and ileum	2
Meckel's diverticulum	2
Duodenum and jejunum	4
Small intestine	4
Duodenum and ileum	1

Lymphosarcoma of the Small Intestine.—Since the ileum contains numerous lymph follicles one would naturally conclude that this part of the small bowel would be a common site for malignant lymphoid tumors. An investigation of the 69 lymphosarcomata recorded during the past ten years reveals the fact that 32 of them occurred in the ileum, and where the lesions were multiple, ten more occurred in the ileum and other parts of the small bowel. The duodenum was the site of lymphosarcoma in 11 instances and the jejunum in 16 (Table V).

TABLE V

LYMPHOSARCOMA OF THE SMALL INTESTINE: LOCATION

Duodenum	11
Jejunum	16
Ileum	32
Multiple areas, including ileum	10

In the literature there has been considerable discussion as to the rarity of leiomyosarcoma and its location. In the cases reviewed 23 were myogenous in origin and occurred equally in the three subdivisions of the small bowel. Seven occurred in the duodenum, seven in the jejunum, and seven in the ileum. In one case there were multiple lesions in the jejunum and ileum, and one case originated in Meckel's diverticulum (Table VI).

TABLE VI

MYO- AND LEIOMYOSARCOMA OF THE SMALL INTESTINE: LOCATION

Duodenum	7
Jejunum	7
Ileum	7
Jejunum and ileum	1
Meckel's diverticulum	1

The fibrosarcomata, including the neurofibro- and spindle-cell sarcoma, occurred practically as frequently in one part of the small intestine as in another. Three originated in the duodenum, two in the jejunum, and four in the ileum, and in one case multiple lesions occurred in the jejunum and ileum (Table VII).

From these statistics one must conclude that, other than lymphosarcoma, all other types occur as frequently in one part of the small intestine as another. The high incidence of lymphosarcoma in the ileum is easy of explanation.

TABLE VII

FIBROSARCOMA INCLUDING NEUROFIBRO- AND SPINDLE CELL OF THE SMALL INTESTINE: LOCATION

Duodenum	3
Jejunum	2
Ileum	4
Jejunum and ileum	1

Pathology.—The sarcomata which are possible in the small bowel according to histogenesis are: Lympho-; neurofibro-; leiomyo-; reticulum; fibro-; endothelial; lipo-; and neurosarcomata. The last two named, one derived from

fat tissue, the other from nerve ganglia in the bowel wall, seem not to have occurred, or to have been reported, so there is no basis for description.

Lymphosarcoma.—The bowel may be involved in a very widespread sarcomatosis of the lymphoid type, but in this condition the primary focus is usually elsewhere and the bowel lesions are commonly symptomless. Lymphosarcoma may occur primarily in the lymphoid tissue of the small bowel, and, if so, it is inclined to remain localized to this part of the bowel only, or to the bowel and adjacent nodes; in contrast to the very widespread lesions that characterize this tumor when originating elsewhere.

The mass is soft and friable, resembling lymphoid tissue, but of a lighter gray color. Friability is lost if there is much stroma or if the tumor infiltrates the muscle. The bulk of the tumor tissue is in the mucosa and submucosa, sometimes encroaching on the lumen by a complete tube-like layer inside the muscularis, but infiltrating it. Usually tumor is noted in the serosa either in small nodules or a large mass. Obstruction is common and is produced by destruction of the bowel wall and kinking, or by tumor mass protruding into the lumen. Ulceration is frequent and perforation by necrosis of tumor may occur. The growth is not sharply limited as a rule because of infiltration or, perhaps, because of gradual neoplastic development in the lymphoid tissue at the periphery of the primary focus.

The parenchymal cell is the lymphocyte and usually differentiation is sufficient to make diagnosis definite. The cells may be only slightly larger than normal or markedly larger, in which case the term "large cell" sarcoma has been used. Nuclei are round, moderately hyperchromatic, and mitotic figures are common. Cytoplasm is not abundant, but if the cells are large it is moderate in amount and stains faintly. At the periphery of the tumor the stroma consists only of invaded tissue. If this has been destroyed the stroma consists of a large amount of new connective tissue and in areas is not visible at all in ordinary stains. Vascular supply is very meager and the few vessels consist of an endothelial lining without much support. Hemorrhage is, therefore, common, but not massive.

Since the growth is somewhat less malignant than lymphosarcoma elsewhere and tends to remain localized in the bowel, obstruction occurs and resection is warranted and may be successful.

The accepted cell origin of this neoplasm is the lymphocyte of the lymph follicle; however, it has been stated that origin may be independent of them. The explanation is that lymphosarcoma may develop from infiltrating lymphocytes in tissues other than lymph follicles. This has been observed in the prostate where there is no lymphoid tissue normally.

Reticulum Cell Sarcoma.—This tumor may be classified as a type of lymphosarcoma, although others designate it as a type of fibrous connective tissue growth. Whatever its true nature may be, the diagnosis is one that can be made only with the microscope. Its peculiarity consists of a varying amount of delicate reticulum which is made visible by silver staining. The parenchymal cells resemble lymphocytes but the stroma is more abundant than

in the lymphosarcoma; however, it is not dense. The gross appearance is identical to that of lymphosarcoma except that it may be less bulky, slightly more firm, and more localized.

Leiomyosarcoma.—Smooth muscle tumors may be single, but are prone to multiplicity. The malignant ones are very seldom pedunculated, but do have considerable mass which may protrude into the lumen of the bowel or bulge on the exterior. Some descriptions indicate that there is little mass, but much destruction and replacement. The consistency is distinctly softer than that of benign tumors of the same type, though it is often described as firm. Obstruction is produced by extension into the lumen since there is usually displacement because the rapidity of growth exceeds the destruction of normal tissue and necrosis of the tumor. Obstruction by angulation and kinking is recorded, but is less characteristic of muscle tumors. Ulceration and moderate hemorrhage are common.

The cells are arranged in bundles extending in different directions, and supported by a small amount of connective stroma, in which vessels are in moderate numbers. Nuclei are elongated and rounded with a stippled chromatin pattern. Mitoses are much in evidence and multinucleated giant cells result from incomplete division. The cytoplasm is an elongated fibrillar structure resembling muscle cells, or may be polyhedral, but not stellate shaped. Malignancy is not high grade as a rule so that resection is successful. The very malignant sarcoma of this type is rare.

Fibrosarcoma.—This tumor has a wide variation in malignancy, but purely benign tumors of this type are quite rare. Their behavior, then, is quite variable. The less malignant specimens are encapsulated, light colored, and hard. They displace tissue, infiltrate slightly, and grow slowly. The location is exterior to the muscle, and they are attached by a broad base.

The type cell is elongated, having several processes. Nuclei are oval, stippled, and mitoses few. Intercellular fibrillar substance taking the specific stain for collagen is a constant feature. Often this substance is abundant and dense.

The more malignant specimens are soft, light-colored tumors, often hemorrhagic and always infiltrating. They occur chiefly exterior or interior to the muscularis, seldom from the fascia of the muscle. The cells are not arranged in any definite fashion, although occasionally bundles are noted. Nuclei are round or oval with dense chromatin material. Mitotic figures are numerous. Cytoplasm is elongated into short processes and there is fibrillar structure which is coarse and stains like collagen. Blood vessels are few, very imperfectly formed so that hemorrhage into the tumor is marked, but massive hemorrhages into the bowel are not likely unless the tumor is traumatized. Necrosis of the central portion occurs, often leaving a peripheral zone of living tumor tissue. Malignancy is high grade and metastases are early.

Neurofibrosarcoma.—This tumor has been mentioned in the literature for over four generations, and intestinal lesions of this type were pointed out by von Recklinghausen. Most commonly there are multiple tumors in the body,

but they may be multiple in the small intestine only, or solitary in this organ. The gross characteristics are variable. Certain examples are encapsulated, gray-colored, friable tissue that is very vascular and contains large lakes of blood and blood extravasations. The common origin is from the nerve trunks in the muscle coat. They may protrude as pedunculated tumors into the peritoneal cavity and interfere little or none with the passage of bowel content. Those of higher grade malignancy invade and destroy the bowel wall, then protrude into the lumen, causing obstruction, or form a band-like section several centimeters in length. The mass may be as large as 25 cm. in diameter and become adherent to neighboring structures. Necrosis with hemorrhage in the center is frequent, often leaving only a shell of living tissue at the periphery. If the bowel wall is invaded this necrotic tissue may be discharged into the lumen and thus ulceration is started.

The parenchymal cell is large, often stellate-shaped, having blunt processes. Nuclei are elongated and have stippled chromatin patterns. Mitoses are occasional. The stroma is a small amount of new connective tissue in which there are many large blood vessels and cavernous spaces often lined only by endothelium. The cells are arranged into imperfect whorls and interlacing bundles. Palisading is the rule, but is variable in prominence. Metastases may be none, or if few confined to the regional lymph nodes. Rarely are they extensive if the primary tumor is in the small bowel.

In other instances the mass is small, hard and gray-colored, grossly resembling a scirrhous carcinoma. There is obstruction produced by destruction of the bowel on one side, infiltration, contraction and kinking. The growth is slow so that dilatation and hypertrophy result above the lesion.

Microscopically, the structure is similar. There is the usual palisading, the oval, stippled nuclei, but cells are elongated chiefly. Vessels are few, but thin-walled, and hemorrhage is less. Ulceration and perforation are not usual, but may occur in the more malignant tumors.

If tumors are multiple, and they may be very numerous, and if secondary masses are retroperitoneal, growth is rapid and the usual cachexia ensues unless obstruction intervenes. Obstruction may be delayed for a time by necrotic tissue sloughing into the lumen, leaving short sections of bowel wall composed of neoplastic tissue only. More often than not the tumors are single or few, and malignancy is not of high grade, making resection possible.

Endothelial Sarcoma.—There are no criteria by which the lymphangio-endothelioma may be distinguished from the hemangio-endothelioma except by the content of the vascular structures which may be formed by the tumor cells. The term angiosarcoma avoids this tissue and may be used to designate vessel formation in contrast to the diffuse type of structure consisting of endothelial cells, but not forming vessels.

It is obvious from certain illustrations in the literature that occasionally epithelial tumors, or carcinomata, are designated as endothelial sarcomata. This error is attributed to the fact that the two types of cells have similar function, namely, that of covering surfaces. Tumors derived from the surface cells

of the peritoneum, or serosa, have been described, but they are widespread growths not limited to the bowel alone and so do not come within the scope of this discussion.

If malignancy is low grade the tumor may be discolored by hemorrhage, or have blue areas from blood in large spaces. Usually the tumor is firm and light colored because of the lack of blood. The appearance is granular or nodular and distinctly infiltrating. In the diffuse type there is no nodulation and the consistency is soft. Obstruction may occur from thickening of the bowel wall by infiltrative growth.

In the diffuse type the cells are polyhedral, have clear cytoplasm, and are not organized into any tissue structure. It is evident that this tumor has been designated as a large, round cell sarcoma or lymphosarcoma. The vascular forms are composed of flat cells also with clear cytoplasm, usually having hyperchromatic nuclei, and they are arranged into whorl, or pearl-like masses, by layering about a focus or lumen of a vessel. Excision is difficult because, grossly, the boundary is not readily visible. Delicate processes extend along fascial planes for some distance, and are amputated when the main mass is removed, thus making recurrence frequent. Metastasis of the vascular types is not common or widespread. The diffuse growth is quite malignant.

Hodgkin's Disease.—Since the small bowel contains lymphoid tissue, it is conceivable that Hodgkin's disease could begin here. The literature contains several reports which will admit of this interpretation, but the regional lymph nodes were involved also; therefore, it is not possible to state with certainty that the disease did not begin in the lymph nodes and produce secondary foci in the bowel. Also, there is the problem of stating what is the nature of Hodgkin's disease. Evidence of its being a true neoplasm or a chronic infectious granuloma is ponderous and inconclusive. Recently the argument has been avoided by accepting the view expressed by Ewing that Hodgkin's disease of the lymph nodes is primarily an infectious granuloma of unknown etiology; that it may remain as such, or it may become neoplastic and then properly be called Hodgkin's sarcoma, which he considers to be of endothelial origin and could be classed with the endotheliomata. The cells, however, have lost their endothelial characters.

The growth involves the lymphoid tissue of the bowel chiefly, but is invasive into surrounding structures. It produces obstruction by mass protrusion into the lumen and thickening of the bowel wall by tumor growth. The histologic structure is identical with the same lesion in the lymph nodes. Fibrosis is present, but to a variable degree, or if marked, there is a dearth of parenchymal cells. These consist of a few large and small lymphocytes, an occasional plasma cell, proliferating endothelial cells, and occasional multinucleated giant cells having vesicular or hyperchromatic nuclei. These cells have been termed Sternberg giant cells and Dorothy Reed giant cells. Rather abundant are large mononuclear cells of the same type. These cells are characteristic, but their exact nature is not agreed upon. They have been regarded as derivatives of endothelial cells, reticulum cells and lymphocytes. As the disease

progresses lymphocytes tend to disappear and the characteristic cells to become relatively more numerous. Polynuclear neutrophils and eosinophils may be present, but are not essential.

COMMENT.—Neurofibrosarcoma is generally accepted to be of nerve sheath origin (sheath of Schwann) and recently has received much attention. Reports of its appearance in various parts of the body are almost daily occurrences and the list is growing larger chiefly at the expense of the lists of fibrosarcomata and leiomyosarcomata. The fibromata of the ovary and the kidney are the only ones that have not succumbed to the modern fashion of the alias.

Reports and illustrations in the literature are not sufficient in detail to permit of analytical study and reclassification, yet if this were possible the present-day lack of uniformity of opinion about histogenesis and classification would make the labor fruitless. Hence, any analytical review of the literature at present must be considered to have an erroneous classification of the different types of sarcoma and will continue in error until such time when additional knowledge is at hand to aid in more correct interpretation of cell structure.

At present, the confusion rests chiefly in the differentiation between fibrosarcoma, leiomyosarcoma, and neurofibrosarcoma. Theoretically, histogenesis is clear, but differentiation in neoplastic growth is not definite enough to permit accurate interpretation.

Treatment.—There is but one treatment for intestinal malignancy, be it carcinoma or sarcoma, regardless of its location in the small or large bowel—that is radical extirpation. This procedure should include as much of the node-bearing area of the mesentery as possible. From all reports sarcomata of the small intestine other than lymphosarcoma do not metastasize to the nodes early, thus, early excision can be curative. Lymphosarcoma, however, quickly invades the nodes of the mesentery, and also spreads to the liver, spleen, and kidneys, but rarely are the superficial nodes involved. In advanced cases the serosa of the bowel becomes infiltrated by tumor tissue and other structures are invaded by contiguity. Frequently the bladder or other pelvic structures become involved. Stabler reports a case in a female, age 76, in which part of the jejunum and a large part of the transverse colon was excised and the patient was well a year later. He states: "Operative risk ceases to exist in the face of a lethal condition."

Radiation Therapy.—We believe that irradiation has a place in the treatment of sarcomata of the small intestine, especially of the lymphoid type. In one of our cases there was wide-spread involvement of the mesenteric lymph nodes, all of which could not be excised. This patient had a moderate dose of postoperative irradiation but died eight weeks later. Two others received radiation and are apparently well.

There are several cases in the literature where the location of the growth prevented its removal and the only treatment was roentgenotherapy. Fair success was obtained. C. W. Mayo mentions a case in which the stomach was involved and treatment with radium was of some value. Minot and Isaacs state that roentgenotherapy alleviates symptoms, diminishes the size of the

growth, and improves the general condition; but does not influence the duration of the disease. Desjardins and Ford believe that, although roentgenotherapy may or may not prolong life, it does keep the disease under control.

Chont discusses radiation therapy of leiomyosarcoma of the small intestine. Geschickter states that they are radioresistant, and Phillips is of the opinion that they are more radioresistant than lymphosarcomata. We believe that no tumor can be classified as radioresistant until treatment is given and the effect noted. As stated previously, it is exceedingly difficult for the pathologist to say whether a tumor is a neurofibrosarcoma, a fibrosarcoma or a leiomyosarcoma. Certain neurofibrosarcomata arising in the superficial nerves are radiosensitive, and one would naturally conclude that such tumors originating in the bowel would likewise be radiosensitive. Hence we are firmly convinced that roentgenotherapy has a definite place in the treatment of intestinal sarcomata.

CASE REPORTS

Case 1.—L. S., male, age 45, was seen February 10, 1941, in consultation with Dr. Isadore Goldstein. He gave the following history: He was awakened during the previous night by griping pain in the abdomen. The pain continued at intervals during the night and the next morning he consulted his family physician (not Dr. Goldstein), who gave him a large dose of castor oil. The pain became steadily worse and at noon he quit work and went home. The pain became more intense and at times it was so severe that it would double him up. About 2 P.M. he had a most agonizing pain which bent him double and he could not straighten out in bed.

Further questioning revealed the fact that he had never been subject to indigestion, could eat anything he wanted, never had pain after meals, nor was he troubled with nausea. He did take a laxative about every two weeks, although this was not necessary. There had never been any blood in the stool. The day before the onset of his trouble he did not feel very well, was a little nauseated, but other than that had no complaint. Further questioning elicited the fact that about ten weeks previously he had had a cold and while coughing he noticed a lump appear in the right side of his lower abdomen. This lump he could feel very distinctly. He consulted his physician who strapped his abdomen with adhesive tape, having made a diagnosis of strained muscles. The previous and family histories were essentially negative.

Physical Examination.—This revealed a healthy-looking middle-aged man, apparently in extreme pain. He lay with his thighs flexed on his abdomen and stated that he could not straighten out. There was marked rigidity of all abdominal muscles and diffuse tenderness. Rectal examination revealed some induration high up above the prostate. No definite mass could be palpated. A diagnosis of acute abdominal perforation was made and surgery advised.

On admission to the hospital his temperature was 100.2° F., pulse 96, respiration 20. Examination of the heart and lungs revealed no abnormality. *Laboratory Data:* Hemoglobin 90, R.B.C. 4,480,000; W.B.C. 12,200, neutrophils 74, monocytes 8, lymphocytes 18. Uranalysis negative. Blood Kahn negative. *Clinical Diagnosis.*—Intestinal perforation.

Operation.—Under novocain and nupercaine spinal anesthesia, a four-inch incision was made at the outer border of the lower right rectus muscle. The abdomen contained a large amount of thin, opalescent fluid in which were small drops of oil, which was removed by aspiration. There was a mass about the size of an orange in the pelvis, and some of the epiploic appendages of the sigmoid were adherent to it. The tumor was in the distal part of the ileum. The adhesions between the tumor and the epiploic appendages and adhesions between the tumor and peritoneum covering the bladder were separated, and the tumor itself was delivered from the abdomen. Further exploration

of the pelvis revealed scattered pieces of tumor tissues in the cul-de-sac. All of these were removed. An examination of the intestine revealed no other pathology. The mesenteric lymph nodes were not enlarged. A resection of the terminal ileum was done and a side-to-side isoperistaltic anastomosis was made, using catgut throughout.

The remainder of the fluid in the abdomen was then removed by aspiration. Eight grams of powdered sulfanilamide was introduced into the abdominal cavity and the wound closed in layers without drainage.

Pathologic Examination.—Gross: Dr. Laman A. Gray. There was a portion from the small intestine measuring 12 cm. long. One end of the intestine, for a distance of 9 cm., was essentially normal except for the gradual appearance of a whitish, thickened condition of the muscular wall until it finally entered a nodule in the bowel wall measuring 6 cm. This nodular tumor had a grayish-white appearance and one side was ragged, having been torn, and containing numerous hemorrhagic spots (Fig. 1). A portion of the intestine for 2.5 cm. was present on the other side and showed it to be essentially normal. There were also several small pieces of grayish-white tumor tissue measuring up to 2 cm.

Microscopically, sections from several masses of tissues showed them to have a quite solid appearance, made up of elongated spindle-like cells with rather large vesicular nuclei which were also long and oval. In some areas there was variation in the size and shape of the nuclei, some being quite dark. There were very definite scattered mitoses (Fig. 2). *Pathologic Diagnosis:* Spindle cell sarcoma (this might be considered a neurofibrosarcoma but I am more inclined to the diagnosis as stated).

After a very stormy convalescence, during which he received two blood transfusions, the patient gradually recovered. The wound became infected and drained for some time. He was dismissed from the hospital March 5, 1941, 23 days after admission. Four weeks later roentgenotherapy was begun, and the patient received in all 4,500 r units, delivered through three fields—right anterior, left anterior and perineal. Distance 50 cm., filtration 1 Mm. of aluminum and 0.5 Mm. of copper.

At the present time he is perfectly well. Careful examination of the abdomen fails to reveal the presence of any tumor nor is there any free fluid within the abdomen. The liver is not palpable. Rectal examination fails to reveal any induration in the cul-de-sac. The superficial lymph nodes are not enlarged.

Case 2.—H. K., white, male, age 40, was first seen in consultation with Dr. David Cohen of Louisville, February 28, 1941, on account of griping pain in the abdomen. The patient had always been well until about six months ago when he began to have pain and cramps in the right lower part of his abdomen. At this time he was under the care of another physician. Roentgenologic studies of the gastro-intestinal tract revealed some irregularity in the duodenal cap but nothing positively conclusive of ulcer. He was started on an ulcer regimen but did not improve. About three months ago he had a severe hemorrhage from the gastro-intestinal tract. There was no hematemesis, all of the blood being passed per rectum. He was extremely pallid and weak and was given supportive treatment and kept quiet in bed for about three weeks. During this time he continued to have griping pain in the lower abdomen coming on one-half to one hour after meals. His strength gradually improved and he was finally able to be up and about. Ten days ago he was examined by a different roentgenologist. The stomach and duodenum were negative for ulcer. The colon was normal. A study of the small intestinal tract revealed in a large number of films an identical pattern in a loop of bowel which lay in the right lower quadrant. The roentgenologist thought he could palpate a mass. It was at this time that the patient was referred to me.

The patient had lost his appetite because he feared the pain in his abdomen that came on after meals. He was slightly constipated but no more so then than he had always been. There were no other symptoms except weakness and loss of 20 pounds in weight. His past, and family histories were essentially negative, other than that his father had died from cancer of the lung at age 62.

Physical Examination.—This revealed a middle-aged man, rather poorly nourished. Examinations of the head, neck, heart and lungs were entirely negative. Examination of the abdomen revealed a mass in the right lower quadrant which was movable and apparently nodular. It was not tender. There were no other masses, no tenderness

FIG. 1.

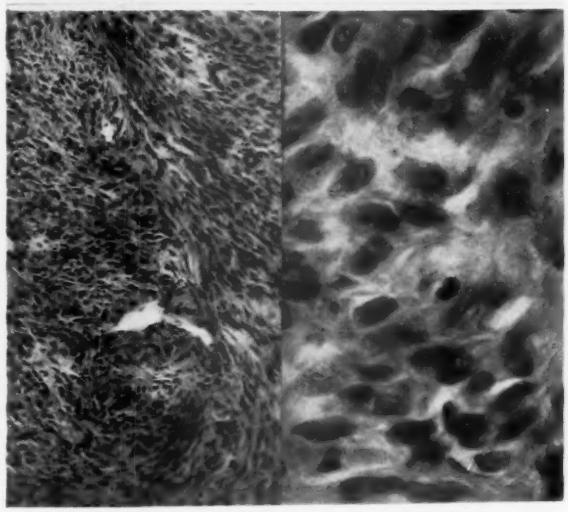


FIG. 2.

FIG. 1.—Case 1: Spindle cell (?) (neurofibro- or leiomyo-) sarcoma of ileum. Normal intestine to the right. Growth of into lumen well shown, also area of hemorrhage.

FIG. 2.—Case 1: Neurofibrosarcoma of the ileum. Cells are arranged into bundles and whorls. Vessels are numerous. Nuclei are elongated. Chromatin stippled. Much resemblance to smooth muscle cells.

and no rigidity. The liver was not palpable nor was the spleen. There were no enlarged nodes in the groin, axillae or in the neck. *Laboratory Data:* Hemoglobin 62; R.B.C. 4,580,000; W.B.C. 18,450, neutrophils 83, lymphocytes 17. There is some anisocytosis and hypochromia of the red cells. Uranalysis negative. Blood Kahn negative. Blood urea nitrogen 15 mg. per 100 cc. blood. *Clinical Diagnosis:* Tumor of the small intestine, probably sarcoma.

Operation.—A five-inch incision through the lower right rectus muscle exposed a

tumor of the small intestine about 10x5x5 cm. There were some fine adhesions between the tumor and the epiploic appendages of the sigmoid. The appendages were doubly ligated and divided. The tumor originated either in the lower part of the jejunum or the beginning of the ileum. Grossly, it was yellow in color and was almost completely obstructing the intestine. There were some small soft nodes in the mesentery of this loop of bowel. A wide resection of the small intestine was done including as much of the mesentery as possible. A side-to-side isoperistaltic anastomosis was performed and

FIG. 3.

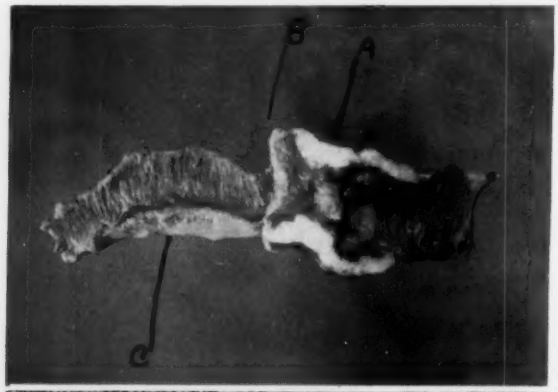


FIG. 4.

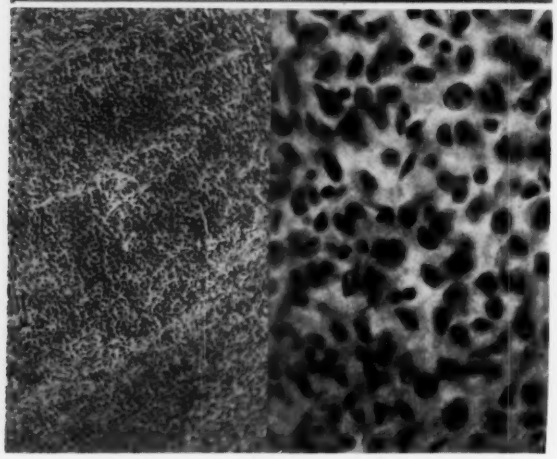


FIG. 3.—Case 2: Reticulum cell sarcoma jejunum. Dilated jejunum to right. (A) Shows wall infiltrated with tumor. (B) Angulation causing partial obstruction. (C) Secondary small growth of similar type. Hypertrophy of solitary lymph follicles well demonstrated.

FIG. 4.—Case 2: Lymphosarcoma of jejunum. Cells are closely packed in irregular masses, supported by small amount of new stroma. Cells are round, have delicate cytoplasm. Numerous mitoses.

the opening in the mesentery closed. The liver and spleen were normal. Eight Gm. powdered sulfanilamide was put in the abdomen and the wall was closed in layers.

Other than a mild postoperative pneumonia the patient made an excellent recovery and left the hospital 16 days after operation.

Pathologic Examination.—Gross: Dr. Harry M. Weeter. Section of small intestine

showed the characteristics of jejunum, consisting of three parts—the proximal portion, approximately 100 Mm. in length and open about 75 Mm. in width—the distal portion, approximately 200 Mm. in length and about 55 Mm. in width—and a central tumor mass completely encircling the intestine which, after being incised, measured 100 Mm. in length by 95 Mm. in width by 20 Mm. in thickness. The proximal and distal portions of the intestine had angulated and become adherent to the tumor mass, so that the two portions just touched each other in the side lateral to the mesentery. The inner surface of the mass was slightly necrotic (Fig. 3). The cut surface presented a smooth tumor whose point of origin was, grossly, the mucosa. Lymph nodes dissected from the regional mesentery were not enlarged.

Microscopically, the tumor appeared to rise in the mucosa, replacing the latter and infiltrating the submucosa and muscularis, and terminating beneath the peritoneum, the subperitoneal tissue being infiltrated by neoplastic cells. Many of the cells were evidently lymphocytes; others were large, rounded to oval cells with a moderate amount of cytoplasm. There was a fine connective tissue stroma. The cells, in places, seemed to lie in contact with the delicate network of the mucosa. In some places they lay loosely in free masses. There was no pronounced alveolar arrangement although some areas suggested this formation. Some nuclei were deeply staining. A number of monasters occurred (Fig. 4). *Pathologic Diagnosis:* Reticulum cell sarcoma of jejunum.

This patient was likewise given postoperative irradiation of 1,500 r units through each of three fields—right anterior, left anterior and perineal. The factors were the same as in Case 1. Examination nine months after operation revealed no masses in the abdomen or could any tumor be felt in the pelvis by rectal examination. There was no enlargement of the superficial lymph nodes. The patient has gained 18 pounds in weight.

Case 3.—R. L., white, male, age 18, was admitted to the hospital, August 23, 1941, being referred by Doctor Sweeney, of Liberty, Ky., with a history that two years ago he began to have cramps in the abdomen and vomiting. This was accompanied by chills and fever. He was sick for only a few days and then went back to work and seemed perfectly well until July, 1940. At this time he again developed cramp-like pains in the abdomen and vomited almost continuously for three weeks. He became exceedingly weak and lost 15 to 18 pounds in weight. This attack was diagnosed as gastro-intestinal trouble and seemed to be relieved by treatment. During the past winter (1940–1941) he complained of weakness and fatigue. He gained a little weight but did not feel well. Immediately after eating he would have pain in the abdomen. These symptoms had been practically constant until six weeks previous to admission to hospital when he again began to lose weight and strength.

Three weeks ago the pain in the abdomen became more severe and he began to vomit. Three days previous to admission he noticed a mass in his abdomen just to the right of the umbilicus. This mass was movable, at times being located in the right lower abdomen and at other times being under the right rib margin.

Physical Examination.—This revealed a somewhat pale, fairly well-developed, undernourished young man. The abdomen was flat, and in the right lower quadrant was a mass approximately 12 cm. in diameter. This was nodular, not tender, and was movable. There was no free fluid in the abdomen. The liver and spleen were not palpable. There was no tenderness or rigidity. The abdomen was reexamined three hours later and at this time the mass was located in the upper right abdomen and seemed to extend beneath the ribs. Rectal examination was negative. *Laboratory Data:* R.B.C. 3,350,000; W.B.C. 12,100, neutrophils 62, eosinophils 3, monocytes 3, lymphocytes 30, metamyelocytes 2. Hemoblogin 9.4 Gm. (62.6%), color index .94, hemoglobin per red cell 28; platelets abundant. Uranalysis negative. Blood Kahn-negative.

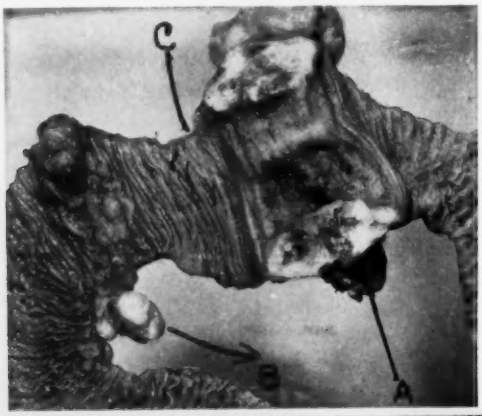
Roentgenologic Examination.—A plain film of the abdomen showed a large amount of gas and fecal material in the colon. The bony structures seemed to be normal. Nothing else of importance was noted. A barium enema filled all parts of the colon

readily. The sigmoid was long and tortuous. The bowel, in general, was hypotonic. The cecum was regular in outline and normal in tone.

Films were made both before and after evacuation. They showed nothing definitely abnormal in the large bowel aside from the fact that a great deal of gas and fecal material were present, evidently indicating that elimination was not satisfactory. The bowel was somewhat hypotonic. Nothing else of importance was noted. No defects were found in the cecum suggesting pressure defects due to extrinsic masses of any type.

An intravenous urinary tract examination was done. The right pelvis was found to be considerably dilated. There was a filling defect that could be due either to intrinsic

FIG. 5.



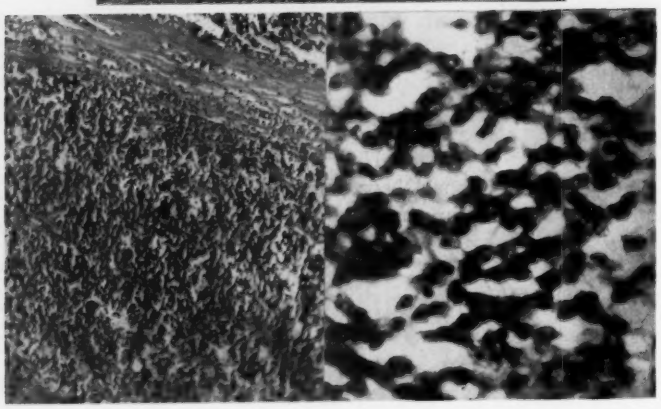


FIG. 6.

FIG. 5.—Case 3: Lymphosarcoma of jejunum. (A) Primary tumor causing partial obstruction. (B) Secondary tumors—not uncommon in this type of growth. (C) Hypertrophy solitary lymph follicle.

FIG. 6.—Case 3: Lymphosarcoma of the jejunum. Very cellular tumor invading the bowel wall. Cells are round, cytoplasm delicate and small in amount.

pathology or to pressure from without. The ureters were not blocked. The psoas shadows were normal. Nothing else of importance was noted.

Comment: There was a definite pyelectasis on the right which evidently indicates some interference with the emptying of the pelvis. There was a little narrowing at the junction of the pelvis with the ureter which may be due to adhesions in this area or to pressure from without.

A film was made with the patient upright and a lead marker was placed over the tumor mass that could be palpated. This mass was quite freely movable. At times it was found in the upper right quadrant while at other times it descended low into the pelvis. It was at first thought that this was connected with the kidney but this film showed that the tumor mass was well below the pelvis of the kidney.

Operation.—August 26, 1941: The abdomen was opened through a paramedian incision. There was a tumor about 8 to 10 cm. in diameter, originating in the jejunum, about 50 cm. below the ligament of Treitz. There was a second smaller tumor about 8 to 10 cm. further down in the jejunum. The nodes in the mesentery were all enlarged. There was no evidence of any metastasis to the liver or spleen and the tumor was not adherent. Approximately 68 cm. of the jejunum was removed, taking out with this as much of the mesentery as possible, due care being taken not to interfere with larger branches of the superior mesenteric artery. A side-to-side isoperistaltic anastamosis was performed.

Thorough exploration of the abdomen failed to reveal any other pathology. Eight Gm. of powdered sulfanilamide was introduced into the abdomen and the wound closed in layers without drainage.

Pathologic Examination.—Gross: Dr. E. S. Greenwood. Specimen consisted of two and a half feet of small intestine. In the central portion of the specimen were two large tumor masses, the larger one measuring 8 cm. in width and 4.5 cm. in depth, and extending clear around the circumference of the intestine. The smaller one was likewise circumferential and measured 3.5 cm. in width and 2 cm. in depth. The entire intestinal mucosa was studded uniformly with minute miliary tumors, measuring on an average 1 Mm. in diameter, which were situated beneath the thinned-out mucosa. The large tumor masses were partially ulcerated but they also extended through and beyond the intestinal wall. On cut section the tumor tissue was soft, white and densely cellular in appearance, and scattered throughout were areas of hemorrhage and necrosis. Surrounding both tumors in the mesenteric adipose tissue were many large lymph nodes, measuring up to 3.5 cm. in diameter. These lymph nodes were dense white and cellular and on cut section resembled the tumor tissue (Fig. 5).

Microscopically, the sections through each of the large tumor masses and through the large lymph nodes had the structure of a lymphosarcoma. In the two intestinal tumors the neoplastic masses appeared to have originated in the mucosal lymph follicles. In areas the mucosal epithelium and villi still covered the mass, in other areas only remnants of glands remained on the surface and over large areas the surface had ulcerated, apparently from pressure of the mass. At the edges of the tumor the neoplasm was confined to mucosa and submucosa; however, at the center the neoplastic cells had definitely invaded the muscularis and serosa. In the lymph nodes the cells had invaded the capsule and surrounding adipose tissue.

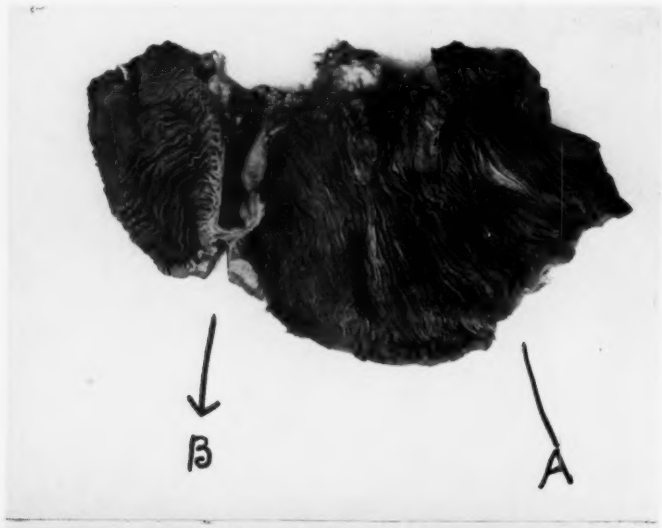
The tumor cells resembled lymphoblasts. They were variable in amount of cytoplasm, size and shape and staining. Mitotic figures were present in small numbers. There were areas in which the cells were pyknotic and necrotic. The entire mucosa of the intestine was fairly heavily infiltrated with lymphocytic cells resembling those found in the tumor masses (Fig. 6). Now and then, in addition, there were lymph follicles (visible grossly).

Sections of the mesenteric nodes showed the structure of the node still present, with germinal follicles in many areas. Here, in addition to altered lymph cells, there were active proliferation of the reticular cells and dilatation of the lymph spaces. *Pathologic Diagnosis*—Jejunum: Lymphosarcoma; generalized with two large tumor masses as well. Mesenteric lymph nodes: Involved in lymphosarcoma.

This patient made an excellent recovery and left the hospital in 12 days following his operation. He was readmitted, September 19, 1941, at which time a roentgenogram of the chest failed to reveal any evidence of metastasis or pulmonary disease. He was given roentgenotherapy through one large anterior portal extending from the xiphoid to

the symphysis. The total dosage was 2,400 r, the target 50 cm. from the skin, and the filtration 1 Mm. of aluminum and 0.5 Mm. of copper. A report from his family physician stated that he died of his disease six weeks after arriving home.

FIG 7.



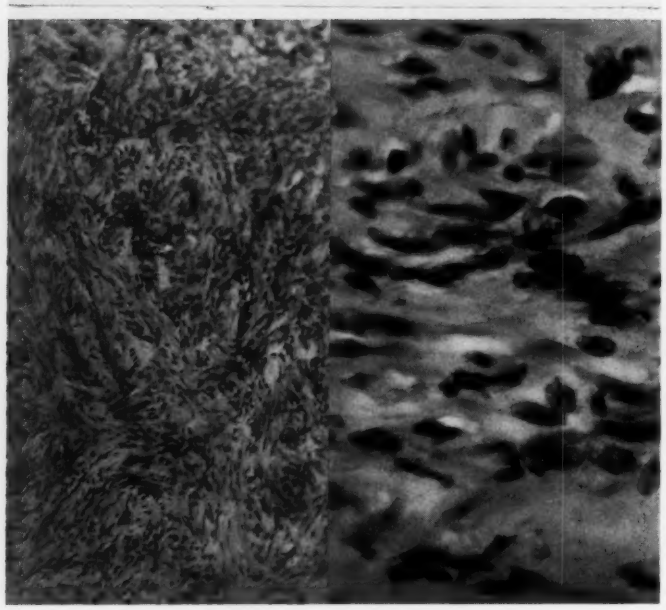


FIG. 8.

FIG. 7.—Case 4.—Neurofibrosarcoma of jejunum. (A) Shows marked dilatation of proximal loop. (B) Shows tumor of annular constricting type.
FIG. 8.—Case 4: Neurofibrosarcoma of jejunum. Cells are arranged into bundles and whorls. Nuclei are elongated, cytoplasm abundant but has indistinct boundary.

Case 4.—Case No. 10835: V. C., white, female, age 14, was admitted to the Louisville City Hospital, January 27, 1941, with history of having had "flu" one month pre-

viously. During this attack she vomited two to three times daily. All symptoms of the "flu" subsided but the girl continued to vomit, and for two weeks previous to admission she had vomited everything taken by mouth. This was unaccompanied by any nausea, and usually occurred 15 to 20 minutes after eating. It was not projectile, and had never contained blood. She had never noticed any blood in the feces. She lost about 28 pounds since the beginning of illness. Past and family histories were negative.

Physical Examination.—Temperature 98° F., pulse 90, respiration 20, blood pressure 106/72. The patient appeared dehydrated, but was otherwise objectively negative.

Laboratory Data: R.B.C. 5,200,000, hemoglobin 14.5 Gm.; W.B.C. 12,000, polys 79%, lymphocytes 18%, monocytes 3%. Uranalysis negative. Blood Kahn and spinal fluid Kahn negative. Spinal tap negative.

Roentgenologic examination showed no evidence of free air under diaphragm. There was an average amount of gaseous retention in the gastro-intestinal tract. Several fluid levels, apparently in the colon, were noted. One fluid level was probably in the distal part of the ileum. It is not certain that this represents intestinal obstruction. Barium enema revealed a dilated and atonic colon. There were a few diverticula in the region of splenic flexure. The contour of terminal ileum was slightly irregular. There was a large round diverticulum with narrow opening about 2 cm. proximal to ileocecal valve.

An upper gastro-intestinal study was made February 7, 1941. This revealed a 50 per cent retention of barium in the stomach. In 24 hours, 30 per cent of the barium remained in the stomach and only a small amount was in the colon.

It was thought that the patient had an obstruction of the small bowel. The exact location is difficult to determine. March 5, 1941, a reexamination of the upper gastro-intestinal tract revealed the jejunum to be markedly dilated. There was an obstruction apparently in the jejunum which was much more evident than at the previous examination.

Operation.—Dr. Arnold Griswold. A side-to-side anastomosis was made around the tumor mass in the jejunum which was located 18 inches distal to the ligament of Treitz. Tumor grossly resembled a scirrhous type of tumor similar to carcinoma of the sigmoid.

Three weeks later the tumor and anastomosis were excised and an end-to-end anastomosis of the jejunum carried out, using the Furniss-Clute clamp.

Pathologic Examination.—The segment of jejunum measured 50 cm. in length. Near the midpoint was a firm constriction 3.5 cm. in length and formed by firm, light-colored tumor tissue which had partly destroyed the wall and constricted the lumen to a few millimeters. There was no ulceration. The bowel proximal to the constriction was dilated to 5 cm. in diameter, its wall markedly thickened by hypertrophy of the muscle coat. Below the obstruction the bowel lumen was 3 cm. in diameter and the wall normal. The mesenteric lymph nodes were moderately enlarged.

Sections revealed the tumor to be located in the submucosa chiefly, but it was invading the circular muscle coat and the mucosa. Cells were arranged in irregular interlacing strands and bundles. Nuclei were fusiform, most having a stippled chromatin pattern, but some were hyperchromatic. Morphology was quite uniform and no mitoses were noted. The cytoplasm was not abundant and had many fibrillar processes. The tumor had replaced the submucosa and much of the mucosa but only slightly damaged the muscle coat. The infiltrative type of growth and destruction of tissue were the only definite signs of malignancy. There were no metastases in the lymph nodes. *Pathologic Diagnosis:* Neurofibrosarcoma of the jejunum, obstructing.

SUMMARY

All cases of sarcoma of the small intestine that have appeared in the literature since January, 1932, have been reviewed and are listed in the bibliography.

Four additional cases are reported; and the symptoms, pathology and treatment of small intestinal sarcoma are discussed.

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DISCUSSION.—DR. L. WALLACE FRANK (Louisville, Ky.): I have only one thing to add. In 1939, we reported two cases of neurofibrosarcomata of the small intestine. I believe that within the next few years there will be a change in our conception of the pathology of small intestinal sarcomata, and that many now considered leiomyosarcomata or spindle cell sarcomata will be diagnosed as neurofibrosarcomata.

EXTENSION OF THE BORDER LINE OF OPERABILITY IN CANCER OF THE RECTUM*

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STARTING with the premise that operative removal of cancer of the rectum is at present the best means of effecting a long-term cure, it is obvious that the broader the indications for operation are extended, with reasonable safety, the more patients will ultimately survive. Contrariwise, it is also clear that careful selection of patients for radical operation will mean a low resectability rate, a low mortality rate, a long survival rate, but, of real consequence, only a limited number of patients given a chance to get well. The problem to be discussed is concerned with the limits of operability.

TABLE I

CAUSES OF QUESTIONABLE OPERABILITY IN 105 PATIENTS

	No. of Cases
Over 65 years of age	38
One or two nodules in the liver	15
Adiposity	10
Obliterative pelvic peritonitis	9
Resection of prostate or urethra with the rectum	7
Resection of rectovaginal septum with the rectum	6
Peritoneal plaques over the tumor	5
Diabetes	5
Removal of all or part of uterus or adnexa	4
Adherent to prostate (removal capsule)	4
Adherent to bladder	4
Adherent to rectovaginal septum	6
Adherent to sacrum	4
Adherent to uterus	1
Resection of another loop of bowel	1
Marked coronary disease	2
Pregnancy	2
Removal of local recurrence	3
Fixed to abdominal wall	2
Asthma and bronchiectasis	1
Involvement of inguinal nodes	2
Double carcinoma of the rectum	1
Involvement of rectal fistula by adenocarcinoma of rectum	1
Total	133

During the last ten years we have been undertaking radical operations for cancer of the rectum in patients who formerly were considered inoperable due to age, adiposity, attachment of the tumor to surrounding parts, and other

* Read before the Southern Surgical Association, Pinehurst, N. C., December 9–11, 1941.

factors to be discussed. During this period, from 1930 to August, 1941, we have had 277 patients come to the Presbyterian Hospital, on our service, for operation. Not included in this study are those patients seen in consultation, some operable, some inoperable, who either refused operation or went elsewhere. Of the 277 patients coming in for operation, five were deemed inoperable because of the local fixation or involvement of unremovable tissue. In 179 patients the tumor was removed, with an operability rate of 65.8 per cent, and a hospital mortality rate of 7.2 per cent. Of these 179 patients, there were 129 one-stage abdominoperineal resections, with a mortality rate of 13, or 10 per cent, 28 two-stage Mummery operations, 16 obstruction resections at the rectosigmoid, five local removals of small tumors, and one resection at the peritoneal reflection, with no deaths. Of the 93 inoperable lesions, 84 patients were given a colostomy, with two deaths. The causes of inoperability were, namely, liver metastases, fixation of the tumor to the base of the bladder, or extensive involvement of the prostate, vagina or sacrum.

If we divide the 179 radical resections into a group of 74 favorable cases, with no question of resectability, and another group of 105 having one or more doubtful factors which clouded resectability, we find the postoperative mortality 4.3 per cent in the first group, and 9.5 per cent in the doubtful group. As all of the operative mortality was in the one-stage abdominoperineal group, the mortality in the favorable cases (53) was 5.7 per cent and 13 per cent in the doubtful group (76).

Old age is, and should be, considered as a doubtful factor in operability. There was only one patient refused operative treatment because of age. He was 81 years old, very feeble, and suffering with chronic bronchitis, and he was simply colostomized. Of the 179 patients having operative removal of the tumor, there were 38 patients over 65 years of age, which was the arbitrary age chosen as adding a hazard to the operation, as 28 patients between 60 and 65 went through the operation without much difference in mortality rate from the younger age-group. In the 38 patients over 65, there were 18 between 65 and 70 years of age, 12 between 70 and 75, four between 75 and 80, and four between 80 and 85. There were four deaths, or 10.6 per cent operative mortality, in this group, the deaths being from embolism in two and pneumonia in two.

TABLE II

AGE AND RADICAL OPERATION FOR CANCER OF THE RECTUM

18 patients between 65–70 years	1 death—embolism
12 patients between 70–75 years	1 death—embolism
4 patients between 75–80 years	1 death—pneumonia
4 patients between 80–85 years	1 death—pneumonia
38 patients over 65 years	4 deaths (10.6 per cent)

The choice of operation in this age-group was somewhat different than in patients under 65, in whom we almost always use the one-stage abdominoperineal operation. Twenty-two patients had a one-stage abdominoperineal resection with four deaths, or 18.2 per cent, seven patients had a two-stage

Mummery operation, three an obstruction resection operation for a lesion at the rectosigmoid, and three a local removal of the tumor, the latter groups with no mortality.

Even though the operative risk in this group of patients has been high, we feel sure that we have given years of life expectancy to a considerable group. Of nine patients over 65 years of age operated upon more than five years ago, five lived over five years. Of four patients of this group operated upon more than four years ago, two lived over four years. In other words, age rarely should be considered a contraindication to operative removal of the tumor.

One of the most difficult decisions to make in favor of radical removal of the tumor is in patients where the tumor is adherent to structures outside the bowel. As already indicated, we found a relatively large number of patients inoperable for this reason, but in the past five years we have become more radical and have resected a large part of the prostate in five patients, the rectovaginal septum in six, the uterus and adnexa in four, the ureter in two, the dome and posterior half of the bladder in one, and another loop of bowel in one. There were two postoperative deaths in this group, one from pneumonia and one from sepsis. Sufficient time has not passed to speak with authority on the long-term cure of these patients but our impression is, from a review of the follow-up, that a considerable number will be given a three- to five-year cure.

There is an added group of 21 patients where the tumor was attached, but not necessarily by infiltration, where part of the prostate (six), the periosteum of the sacrum (five), a portion of the base of the bladder (four), rectovaginal septum (five), or uterus (one), was removed. Of this group there was one postoperative death from peritonitis due to the fact that the tumor had perforated into the hollow of the sacrum. There have been five local recurrences of the growth, and the most unfavorable are those where the tumor is attached to the sacrum. Of the whole group, two are living and well after three years, and four have lived over five years.

There have been 15 patients with one or two small nodules in the liver at the time of operation who have been given the benefit of a radical removal of the tumor. We have not been impressed with the soundness of undertaking radical operations where definite liver involvement is present, due to the tedious convalescence following radical operation coupled with an average expectancy of only ten months in any patient having definite liver involvement at the time of operation. The presence of one or more small nodules in the liver presents an entirely different problem, as the differential diagnosis between early carcinoma of the liver and an adenoma or angioma is very difficult to make by touch. Of the 15 patients in this latter group, four have had recurrence in the liver and have died on an average of ten months postoperatively. Four of these patients are alive three to five years postoperatively, which justifies giving patients with questionable lesions in the liver an operative chance of cure.

Adiposity has not been considered a contraindication to operation in any

patient, although the added risk of intra-abdominal procedures in fat patients is well known. There were ten patients in this group who were exceedingly fat, most of them rather short with large abdomens. There was one postoperative death from embolism and one evisceration which was repaired and from which the patient recovered. Eight patients had one-stage abdominoperineal resections, one a two-stage Mummery operation, and one other a resection of the tumor with closure of the distal rectal segment of the bowel. In the follow-up, two patients died within a year of liver metastases, one of these having had a nodule in the liver at the time of operation. The other seven patients are alive, one five years, two three years, and two two years postoperatively. In operating upon such a group, the surgeon must be prepared for poor exposure of the operative field and a willingness to do much of the dissection by touch. There is, no doubt, an added risk of hemorrhage, infection, evisceration, and cardiovascular accidents. In spite of these dangers there is 100 per cent expectancy of death if no operation is done, and that is the impelling indication for operation in all increased risk patients with carcinoma of the rectum.

In nine patients having a radical removal of the tumor there was an obliterative peritonitis of the small pelvis resulting from a previous operation or due to endometriosis or diverticulitis. This complication is an annoying and somewhat dangerous one in that an hour's time may be necessary for obtaining proper exposure in some of these patients, and the danger of peritonitis by getting into the bowel or tumor is always present. One of these patients died of sepsis due to inadvertent cutting of a ureter.

Four patients were found to have a perforation of the tumor with local abscess formation at the time of operation. The soft-part inflammatory mass was removed with the tumor. One of these patients died of postoperative peritonitis. The other three are still alive three to five years after operation.

Among the miscellaneous factors making operability somewhat doubtful were peritoneal plaques over the tumor (five), diabetes (five), pregnancy (two), removal of local recurrences (three), marked symptoms from coronary disease (two), fixation of the tumor to the abdominal wall (two), ulcerative colitis (one), asthma and bronchiectasis (one), involvement of inguinal nodes (two), double carcinoma of the rectum (one), and involvement of an extensive rectal fistula with transplanted cancer from an adenocarcinoma of the ampulla (one). Of this group there was one postoperative death from peritonitis in a patient with peritoneal plaques over the tumor; the cause of the peritonitis was unknown. The most unfavorable group was five patients having peritoneal plaques over the tumor. In addition to the postoperative death mentioned, three had recurrences in the peritoneum within two years; one patient is living six years after operation.

Of the 105 patients classed as being doubtfully operable, there were 18 having more than one factor influencing that decision. Of that group, there were two hospital deaths.

No previous mention has been made of lymph node involvement as a

contraindication to operative removal of the tumor for the reason that gross enlargement of the nodes may be due to infection. Knowing that 65 per cent of lymph nodes are involved with carcinoma at the time of operation and that many nodes are involved that cannot be determined by palpation alone, we have favored the one-stage abdominoperineal operation as offering the best opportunity of widespread removal of the lymphatic tissue draining the rectum.

TABLE III

OPERABILITY

	To August, 1941	1940	1939	1938	1937	1936	1935	1934	1933	1932	1931	Total
Total operated upon	26	35	36	33	41	30	18	12	16	14	16	277
Radical Resection	17	24	24	24	27	19	12	6	7	9	10	179
Abdominoperineal resection	16	22	18	18	25	15	8	2	4		1	129
Mummery—2-stage			1	1	1	2	4	4	2	7	6	28
Obstruction resection	1	1	4	4	1	2				1	2	16
Local removal		1	1						1	1	1	5
Resection				1								1
Inoperable	9	11	12	9	14	11	6	6	9	5	6	98
Colostomy	8	10	12	3	13	10	5	5	8	5	5	84
Nothing done	1	1		6	1	1	1	1	1		1	14
Questionable Operability	13	13	21	14	15	9	7	3	4	5	1	105
Abdominoperineal resection	12	11	16	10	15	7	3	1	3			78
Mummery—2-stage			1	1		2	4	2	1	4	1	16
Obstruction resection	1	1	3	2								7
Local removal		1	1							1		3
Resection				1								1

In this report we have discussed a group of patients with cancer of the rectum having one or more factors which increase the hazards of operation and in some instances, without doubt, decrease the chances of long-term survival. It is our belief that the indications for operation should be broadened as long as the mortality rate can be kept within reasonable bounds and the long survival rate reasonably high. It is hoped that the experience of others in this doubtful class of patients may be recorded so that the limits of operability may be more clearly defined.

DISCUSSION.—DR. FRED W. RANKIN (Lexington, Ky.): This is such an excellent piece of work which Doctor David has presented that I feel one should probably congratulate him on the presentation and not attempt to discuss it, for there are so many points which need attention, and time is too short to take them up in order. It must be digested in its published form to be fully appreciated. He has gone into the question of operability of cancer of the rectum in a most meticulous manner. He has discussed the extension of the horizon of operability to the point of removal of portions of adjacent viscera, including loops of small bowel, and I am entirely in accord with his thesis. Likewise, I agree with him that the cases which have plaques of carcinoma on the pelvic peritoneum have a particularly poor prognosis, but still I feel that they should be resected, removing all visible plaques. When one is confronted with the question of cancer of the liver in an otherwise operable rectal cancer, the decision is not so simple and easy. The operation is formidable even in the hands of expert surgeons, and the convalescence is long; the metastases have undermined the resistance of the patient; and the

mortality rate is bound to be higher. On the other hand, a death from liver cancer is much more comfortable than one from an obstructing, locally spreading rectal cancer. Undoubtedly, a resection operation in the presence of liver metastasis is frequently justified, but, certainly, it should not be made routine. Occasionally, following such an operation, we are surprised by a duration of life of more than ten or 12 months.

Doctor David, two or three years ago, presented before the American Surgical Association his work on lymph node involvement in cancer of the rectum, which, to my mind, was clinching evidence—if any more argument is needed than clinical experience—that the radical procedure for cancer of the rectum, doing it in one stage, will unquestionably give the most satisfactory end-result. I believe that his demonstration, which showed that the more nodes examined, the more were found to be involved, is a monument of industry, and eliminates, completely, any arguments for local excision of rectal cancer with reestablishment of the bowel lumen, save in a very small group of cases. With 65 per cent or more of involved nodes in cancer of the rectum, there is no question of the futility of these local operations, and they should not be employed save only in cases where any other kind of operation is impossible because of coexisting debilitating disease or local conditions. Doctor David's work on lymph node involvement in cancer of the rectum, to my mind, is one of the most outstanding pieces of work which has ever been done on this disease in this country.

With the extension of operability, obviously, the mortality must be kept within reasonable bounds; the question is, what are reasonable bounds? A mortality, following resection, of less than 10 per cent, is certainly reasonable, and Doctor David has shown that with proper teamwork, proper preoperative care and postoperative observation, the mortality figure can be kept between 5 and 10 per cent. His figures of 4 and 9.3 per cent in the favorable and unfavorable groups are eminently satisfactory, and I think are not likely to be improved upon.

I want to congratulate him on this magnificent paper, and to agree with him that the resectability rate, which permits the removal of 80 or more cancers out of 100, as they come into the clinic, is a distinct advance and will improve the figures on longevity.

Dr. Harvey Stone (Baltimore, Md.): I agree with what Doctor Rankin and Doctor David have said. In the present stage of surgical treatment in this condition, the type of operation is preferably the one-stage abdominoperineal resection, of the general kind advocated by Miles. I do not think there is much difference of opinion on that point. However, as I listened to Doctor David, it seemed to me that his principal thesis was not concerned with the kind of operation but with the problem of when operation should be performed. In other words, under what circumstances should one undertake radical surgery for this condition?

I was particularly glad to hear his paper and Doctor Rankin's discussion, because I find myself in a most unsatisfactory position on this question. I go through cycles. I fully agree with the principle that the only present method of curing the disease is by widespread radical surgery, and on that basis I think every extension, within reason, of criteria of operability is a step in the right direction. But what happens is this: I proceed on that basis, and in a few cases will include a little more, and a little more, in the scope of operability, and feel satisfied until I run into three or four cases in which I operate in doubtful circumstances and something goes wrong. I have had two or three deaths, or a series of distressing prolonged convalescences, with the

patient probably dying after five or six months with the original disease, and that sets me back on my heels. I begin to wonder whether I exercised rational judgment and I begin to swing back. I confess it is highly confusing. In principle, I fully agree that the extension of operability should be widened, but, in practice, I confess that after running into trouble my knees weaken and I begin to shrink back.

Dr. William Marbury (Washington, D. C.): I shall not attempt to comment on Doctor David's paper directly—which has been so ably done by Doctor Rankin and Doctor Stone—but I want to mention a colostomy tube used for cleaning out the left side of the colon. This is more applicable for obstructive growths in the sigmoid, but applies to those in the rectosigmoid region also. The tube is a double lumen tube, on the order of that of Miller-Abbott, but is about the size of a stomach tube. It is passed into the bowel through a cecostomy and gradually worked around to the descending colon. The difficulty is to make it pass the splenic flexure (Fig. 1), and this is facilitated by putting the patient in the Trendelenburg position.

Fig. 1.—Roentgenogram showing the colostomy tube traversing the entire colon down to the obstruction. Barium enema extends up to the obstruction.

We thought that if it were possible to clean out the left side of the colon, a one-stage resection would be made much safer. I think we have all found the colon so full of feces in these obstructed cases that a primary resection was ill-advised. In some of the large clinics a primary resection has been abandoned for a modified Mikulicz's. The mechanical part has worked out satisfactorily in a few cases, but we have not as yet been able to liquefy the feces in the descending colon so as properly to clean it out. Some experiments are being undertaken to accomplish this if possible.

The slide shows the tube extending from the cecostomy to the obstruction in the sigmoid.

Dr. Vernon C. David (Chicago, Ill., closing): I once did most operations of this type at Cook County Hospital, and there our operability rate was much lower, as I think it is in all charity hospitals, than in private practice. Therefore, any figure as to operability rate must concern many other things.

The remarks of Doctor Rankin about cancer of the rectum come, of course, from an authority who has had no small part in making operation in this field successful, because, from the start, he has been an advocate of widespread radical surgery. He has also given us indications for operation in early cases, allowing one to perform resection with eventual closure in a two- or three-stage operation. For that reason his contributions and those of Doctor Stone, and many others, have more and more increased the element of safety.

Doctor Stone brought out a very human side of the discussion, which I

think affects us all, but as surgeons we must have broad backs. When we are faced with 100 per cent loss of patients if the lesion is not removed, I think we all feel better in our minds about giving doubtful cases a chance. I think the larger the indications for operation become, the higher will be the mortality of the operation, but if, at the end of a given time, we have more patients alive, we can certainly feel happy about extending the operability. To lose two or three patients does change one's philosophy, but if, over a period of time, we can show our mortality figures still low, and the range of operability higher, then I think we can say we are on firm ground.

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ANNULAR PANCREAS AS A CLINICAL PROBLEM *

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ANNULAR PANCREAS is an anatomic anomaly of great rarity. The reports of only 48 cases have been found in the anatomic, pathologic and surgical literature and of these only ten cases have been operated upon. The condition presents, therefore, one of the most unusual of clinical problems, the surgical relationships of which are entirely undefined. In no previous case has the diagnosis been suggested preoperatively and there is no agreement on surgical treatment. The present report deals with a single treated case with a correct tentative preoperative diagnosis. The clinical implications of the condition will be stressed.

Case Report.—Hospital No. 155428: B. R., white, male, age 23, unmarried, was admitted to the hospital, February 2, 1940, following study in the Out-Patient Department, where he was first seen eight months previously. The patient is an underdeveloped young white man of illiterate rural stock who is obviously ignorant and of low grade mentality. His I.Q., on the revised Stanford-Binet Intelligence Scale, is within the range of the low moron, and he can neither read nor write, having gone no further in school than the first grade. The many histories obtained during observation are, therefore, variable and unreliable. In general, the complaint seems to be that of sharply limited non-radiating epigastric pain, occurring in attacks of irregular frequency. At times the attacks were at intervals of a month and at other times occurred several times a day. They were apparently not associated with meals, but the patient felt that eating increased the pain and had, therefore, limited his diet. The pain was agonizing in severity, so that his family physician gave him morphine for relief on many occasions. Apparently the drug was employed quite freely without regard to possible habit formation. Belladonna and alkalies had no effect on the pain. There was no known fever with the attacks, and, until just before admission to the hospital, no vomiting. There were no other abdominal symptoms, no disturbances of bowel function, and no abnormal stools. The original Out-Patient diagnosis was pylorospasm and peptic ulcer.

The first roentgenologic examination, November 21, 1939, showed: "On ingestion of the barium meal the esophagus was negative. The stomach filled readily, and except for a somewhat excessive degree of spasticity in the prepyloric area, it appeared within the limits of normal. The proximal portion of the duodenum was seen to dilate as the barium flowed in. This dilatation ended abruptly in the second portion of the duodenum where the barium passed an oval defect two centimeters in diameter in a narrow stream (Fig. 1). The duodenum in this area was not fixed and the defect was within the lumen. Distal to this, and up to the ligament of Treitz, the duodenum was somewhat dilated and there was a slight delay in the passage of barium at the ligament. This distal portion of the duodenum had a somewhat ragged appearance which is not believed to be of clinical significance since this portion was freely movable and the wall seemed pliable. At six hours there was about a five per cent gastric residue and there was a little barium in the duodenum outlining the defect seen at the first examination. The head of the meal was still in the small intestine. At 24 hours the ascending and the descending colons were fairly well outlined and appeared grossly negative. *Roentgenologic Conclusions:* Polyp, two centimeters in diameter, in the second portion of the duodenum, most probably benign. Low-grade obstruction at the ligament of Treitz."

* Read before the Southern Surgical Association, Pinehurst, N. C., December 9–11, 1941.

Just before admission to the hospital the patient had a much more severe attack of pain, with vomiting, and again received hypodermics of morphine. The abdominal examination was negative except for slight epigastric tenderness. The results of the usual laboratory examinations, including the Wassermann and Kahn reactions in the blood, were normal. There was no anemia. A review of the roentgenograms resulted in an opinion that the lesion observed in the duodenum was more probably a constricting ulcer than a polyp.

FIG. 1.—Roentgenogram of case of annular pancreas. Note smooth filling defect (between arrows) in dextral aspect of second portion of duodenum.

On account of the smooth contour of the defect (Fig. 1) the surgeon suggested the diagnosis of annular pancreas and the case was presented before a staff conference with emphasis on this diagnosis as a possibility.

Operation.—Under spinal anesthesia, a transverse upper abdominal incision was made. The gallbladder was normal, as was the liver. The appendix was not seen. No pathologic findings were noted with the exception of those in the duodenum and pancreas. The dilated first portion of the duodenum was readily identified and the duodenum was mobilized by an incision in the peritoneum at the outer side. Palpation of the pancreas then revealed a diffuse nodular enlargement of the organ. In the head of the pancreas the nodules were large and hard and suggested malignancy. The tail of the pancreas was also indurated and enlarged so that its cross-section was nearly circular. During this phase of dissection and examination the site of obstruction was not obvious. It was felt that if the obstruction were due to tumor, further surgery might not be justified. One of the nodules in the head of the pancreas was, therefore, approached from beneath, and a specimen about one centimeter in diameter was obtained. A duct was opened, from which clear fluid escaped, presumably pancreatic juice. The wound in the pancreas was closed with two layers of fine silk sutures. Pending the report of a frozen section, a further search was made in the region of the obstruction. The diagnosis of annular pancreas then became clear (Fig. 2). In the lowest part of the second portion of the duodenum there could be seen what was apparently pancreatic tissue in a band stretching across the duodenum. On the superior surface this band was about three centimeters in diameter and narrowed to about 1.5 centimeters in diameter at the under surface where it disappeared beneath the duodenum. Superficially it appeared thin but after dissection it proved to be about one centimeter in thickness. A plane of cleavage

between this structure and the duodenum was found and it was then divided. Immediately the duodenum unfolded to an extent of about four centimeters, with apparently complete relief of the obstruction (Fig. 3). About one centimeter of the anterior portion of the ring was further dissected off the duodenum and removed for biopsy. The cut ends of the pancreatic ring were closed with mattress sutures of fine silk. The duodenum was then dropped back in place and the abdominal wound was closed with interrupted sutures of fine braided silk in layers.

FIG. 2.—Sketch of operative findings in case of annular pancreas.

Pathology.—The frozen section from the head of the pancreas showed inflammation and fibrosis. The report by Dr. J. R. Cash from the excised segment of the ring is as follows: "A section through the main mass shows a large duct with many small surrounding tributaries, all lined by columnar epithelium. Three smaller, similar ducts, which may well be main branches of the large duct, are also present. All of these ducts are embedded in dense fibrous tissue. Closely adjacent to them are several intact unaltered nodules of pancreatic tissue in which a number of small, but quite typical islands of Langerhans are seen. Embedded in other areas of the fibrous tissue are scattered islands of Langerhans. These vary from about normal size to small groups containing only five or six islet cells. The fibrous tissue is fairly rich in blood vessels and contains a number of small nerve trunks. In this section there is only very slight perivascular and periductal infiltration by lymphocytes. Several small fragments of tissue from the head of the pancreas, of which frozen sections had been made, show a few small ducts similar to those just described, and scattered islands of Langerhans embedded in fibrous tissue and fat. Occasional small groups of acinar cells are also seen. Of special interest in these latter sections is the presence of many more lymphocytes about the blood vessels and ducts as well as quite extensive and diffuse infiltration of all of the tissue with polymorphonuclear neutrophils and leukocytes and numerous monocytes. No evidence of fat necrosis is seen. *Pathologic Diagnosis:* Atrophic pancreatic tissue showing long-standing subacute inflammation" (Fig. 4).

Postoperative Course.—The patient had a smooth immediate recovery and was discharged on the eleventh day, apparently well, with the wound cleanly healed. He was readmitted on the seventeenth postoperative day with recurrence of his epigastric pain, now radiating around the right side of the back, for which he had again received hypodermic injections. On this occasion the temperature was 99.2° F., the leukocyte count was 18,000, and there was definite tenderness in the epigastrium. His complaints were

FIG. 3.—Same as Figure 2; after division of ring and partial suture of cut ends. Note unfolding of duodenum.

extremely violent at first, but ceased immediately following a hypodermic injection of codeine. The next day he was apparently comfortable and was discharged three days later, without complaints. The blood amylase was 29.4 mg. per cent.

The patient continued to return to the Out-Patient Department at frequent intervals, with the same type of complaint. His home physician was giving him morphine whenever he was called. On several occasions in the Out-Patient Department the pain promptly ceased following a hypodermic of sterile water.

On April 11, 1940 a gastro-intestinal roentgenologic examination showed: "On ingestion of the barium meal the esophagus was negative. The stomach filled readily. The pylorus was very spastic. The second portion of the duodenum was pulled far to the right, and there was a low-grade obstruction. Otherwise, no definite abnormalities were demonstrated. At six hours the stomach was empty and the head of the meal in the ileum. At 24 hours barium was scattered throughout the large bowel in insufficient quantity to warrant any further opinion. *Roentgenologic Conclusions:* Low-grade obstruction in the second portion of the duodenum which is drawn far to the right. Very spastic pylorus." Similar findings were reported in July and August, 1940, and again in January, 1941.

The last recorded visit was on May 18, 1941, on which occasion he was found to

have a urinary retention of 1,000 cc. On this occasion, again, complete relief of pain was immediately obtained following a hypodermic of sterile water.

SUMMARY.—Herewith is reported the case of a moronic young man with characteristic symptoms of chronic duodenal obstruction of a year's duration, apparently due to annular pancreas, complicated by chronic interstitial pancreatitis and treated by partial excision of the ring. He had been managed by his home physician with liberal amounts of morphine which, after operation, were continued on any excuse. After discharge the patient had persistent symptoms resembling the original complaint, frequently relieved following a hypodermic of sterile water. Postoperative roentgenologic studies revealed deformity of the duodenum, believed due to adhesions, with slowing of the stream but with no six-hour retention. The patient's mental level, and a probable morphine habituation, make the symptomatic results of the operation impossible to estimate.

Incidence.—McNaught,[16] in 1933, presented a thorough review of the literature of annular pancreas, and a table showing the 40 recorded cases (including one of his own), since the condition was first described by Tiedeman, in 1818. In 1935, he and Cox[17] brought the record up to date, with the addition of three cases from the literature, and reported a second case of their own. Since that date, reports of three additional cases[9, 18, 19] have been found, which, with the case herein described, make a total of 48 cases now on record.

Anatomy.—Briefly, the anomaly consists of the prolongation of an annular process from the head of the pancreas to surround the duodenum, which is usually completely embraced by a ring of pancreatic tissue (Fig. 2). If the ring is not complete, the defect occurs on the anterior surface of the duodenum[13, 15] where the anomalous structure would otherwise fuse with the anterior surface of the head of the pancreas. It differs from most other anomalies of the pancreas in presenting an abnormal structural relationship to the duodenum that is, theoretically and actually, capable of causing mechanical disturbance of the function of the bowel. There is, in fact, in almost all described cases a narrowing of the lumen of the duodenum at the site of the encircling band, and a dilatation of the bowel above the narrow point, the latter often accompanied by thickening of the wall. That this partial duodenal obstruction is apparently not always a cause of symptoms will be emphasized below.

A second point of anatomic importance is the duct structure in the anomalous ring. Except when the subject of pathologic changes common in the anatomically normal pancreas, the ring cannot be distinguished histologically from normal pancreatic tissue; it is obviously an active portion of a secreting gland and possesses a duct system with a principal channel and tributaries comparable to the corresponding structures in the rest of the pancreas. Interest in the anatomy of this duct has been intense, so that many careful studies of its origin and course are available.[11, 12, 17, 18, 19] All adequately studied specimens have shown a constant anterior point of origin of the duct, which subsequently courses to the right over the duodenum, then posteriorly, then to the left behind the duodenum, and finally enters the head of the pancreas in close relationship to the common duct (Fig. 5). Here it almost always empties into the main pancreatic duct,[4] but may terminate otherwise.[19] Inter-

est in the duct has been centered entirely on the attempt to find an embryologic explanation for the anomaly. It will be pointed out that the anatomy of the duct has surgical importance.

Embryology.—The embryologic origin of annular pancreas had been adequately discussed both in the American and foreign literature. Although there is some disagreement, the majority opinion among later writers holds, with Lecco,[10] that the anomaly occurs as the result of a failure of complete migration of the ventral anlage of the gland, the tip of which remains in an anterior position while the duct outlet into the bowel rotates to the right and posteriorly

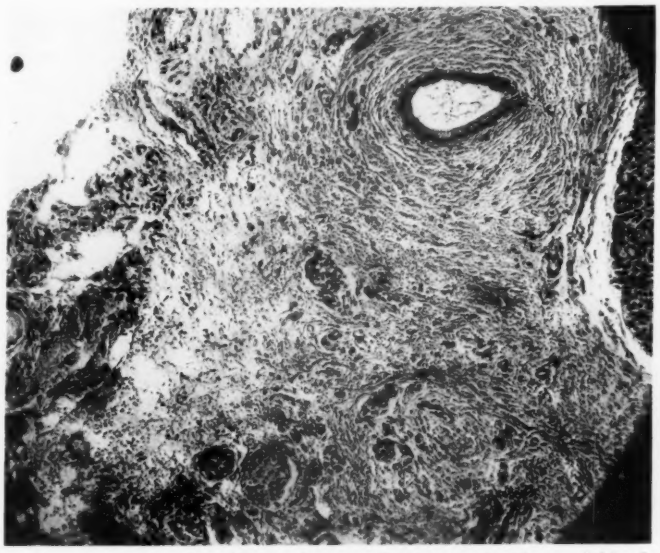

FIG. 4.—Section from biopsy of pancreatic ring showing duct and islands surrounded by fibrous tissue and a small segment of relatively normal acinar tissue.

in the normal manner to become the distal portion of the duct of Wirsung. There is thus left behind a strip of pancreatic tissue encircling the duodenum. The point of origin of the annular duct, its usual outlet into the duct of Wirsung, and the occasional anterior defect in the ring all tend to support this hypothesis. The reader is referred to McNaught's excellent description[16] for a more detailed consideration.

Pathology.—In addition to the obstruction of the duodenum already mentioned as a part of the gross anatomy of the anomaly, associated pathologic changes may be divided into two categories: Those in the anomalous structure itself; and those elsewhere. Although in some cases[14, 15, 17, 4 (Cases 1 and 2)] the annular portion of the pancreas presents no pathologic change, the incidence of chronic interstitial pancreatitis is rather higher than one would expect. The fact that the ring was found to be diseased in all five cases operated upon in which microscopic study of the tissue is reported (Table I) suggests the possible relationship of inflammatory changes in the ring to the development of clinical symptoms, as has been pointed out by others.[5, 7, 16] The rigidity of the inflammatory tissue is an adequate explanation for the

TABLE I

ANALYSIS OF TEN CASES OF ANNULAR PANCREAS, TREATED BY SURGICAL OPERATION

Case No.	Reported by	Sex Age	Clinical Picture	X-ray	Preoper. Diagnosis	Diag. At. Oper. Table	Operation	Path. of Interest	Result	Remarks
1	Vidal[1] 1905	Male. 3 days	Congenital pyloric or duodenal obstruction	None	Congenital high obstruction	Annular pancreas	Post. gastro-enterostomy	No report	Cure	Also congenital atresia of duodenum
2	dos Santos[2] 1906	Female. 26 yrs.	Duodenal obstruction	None	Pyloric or duodenal obst.	Ptosis of stomach	Post. gastro-enterostomy	Chronic interstitial pancreatitis	Died (pneumonia)	Diagnosis at post-mortem
3	Lerat[3] 1908	Female. 46 yrs.	Duodenal obstruction	Neg. for pancreatic calculi	Chr. pancreatitis. Cholecystitis. Appendicitis	Annular pancreas	Resection of pancreatic ring. Cholecystectomy. Appendicectomy	Patchy sclerosis about ducts of pancreas	Cure	Drainage ceased on 13th day
4	Smetana[4] (Case 3) 1928	Male. 74 yrs.	Duodenal obstruction	None	Tumor of duodenum	Tumor of duodenum	Post. gastro-enterostomy	Marked sclerosis of pancreas. Superficial ulcers of duodenum. Ca. of cystic duct	Died several hours after operation	Diagnosis at post-mortem
5	Howard[5] 1930	Female. 46 yrs.	Duodenal obstruction	Diverticulum 2nd portion duodenum	Chronic duodenal ileus	Annular pancreas	Division of ring	No report	Cure complicated by pancreatic fistula	Second operation necessary for drainage
6	Brines[6] 1930	Male. 35 yrs. (Negro)	Acute abdominal emergency 3 days' duration	None	Acute abdominal emergency	Retroperitoneal hemorrhage	Drainage	Chr. interstitial and acute hemorrhagic pancreatitis. Chronic cholecystitis	Died 1¾ hours after operation	Diagnosis at post-mortem
7	Zech[7] 1931	Female. 27 yrs.	Duodenal obstruction	Partial obstruction duodenum. Diminished function gallbladder	Obstruction duodenum from adhesions. Cholecystitis	Annular pancreas	Division of ring. Heincke-Mikulicz on duodenum. Cholecystectomy	No report	Cure (2 years), complicated by small pancreatic fistula	Duodenum did not expand after division of ring
8	Brines[8] 1931	Male. 44 yrs.	Duodenal obstruction	Dilated stomach. Deformed bulb. Gastric retention	Duodenal ulcer, with stenosis	Chronic gastric ulcer	Post. gastro-enterostomy	No report	Died (respiratory infection)	Diagnosis at post-mortem
9	Truelsen[9] 1940	Male. 35 yrs.	Duodenal obstruction	Duodenal diverticulum	Duodenal diverticulum	Annular pancreas	Post. gastro-enterostomy. Narrowing of 1st portion duodenum by open operation	No report	Cure	Postoperative x-ray: Functioning gastro-enterostomy. Duodenal ballooning gone
10	Lehman 1942	Male. 23 yrs.	Duodenal obstruction	Polyp of duodenum or constricting ulcer	Chr. duodenal ileus. Annular pancreas?	Annular pancreas	Partial resection of ring	Chronic interstitial pancreatitis	Recovery, but persistent symptoms	Postoperative x-ray: Persistent deformity of duodenum

origin of obstructive symptoms. In Brines' first case,[6] of acute hemorrhagic pancreatitis involving the ring, the secondary disease apparently precipitated acute duodenal obstruction.

The reason for the occurrence of chronic or acute pancreatitis in a considerable number of instances is not clear. It is possible that the theory of Rich and Duff,[20] in explanation of the etiology of pancreatic inflammation, may be even more logical in this condition than in the nonanomalous pancreas. The pressure behind partially occluded ducts may be exaggerated by the relatively tortuous course of the main duct and by increased intraductal pressure caused by duodenal peristalsis and the crowding of the ballooned duodenum down upon the ring.

In the second category, ulceration of the stomach or duodenum has been frequently reported.[2, 8, 4 (Case 2)] These are, of course, common enough, in general, to make indefinite any direct association between ulceration and the anomaly. It is possible, however, that chronic duodenal obstruction at this level might disturb the acid-base relationships at the pylorus. Truelsen[9] ascribes the occurrence of ulcer to stasis in the stomach and bowel. Finally, as with other congenital malformations, annular pancreas is associated with a high incidence of other anatomic anomalies (25 per cent according to McNaught and Cox[17]) which need not be listed here.

Clinical Picture.—It is a striking fact, that of the 48 cases of record, 38 cases are reported only as the result of incidental observations in the pathologic or anatomic laboratories. Most of these 38 reports present no or meager clinical data; but several of the observations were made following death from other causes at advanced ages (65,[19] 70,[17] and 74 years,[4 (Case 2)] respectively). McNaught[16] states that the reports of his original series of 40 cases from the literature were accompanied by clinical data in 15 instances, and that of these 15 cases, nine (60 per cent) presented abdominal symptoms in varying degree. Among these nine cases, however, are the seven cases that came to operation during this period. Although it is obvious that annular pancreas can cause symptoms, these facts lead to the conclusions that the condition is in many instances compatible with long life, and that probably considerably more than one-half of the cases do not present a disturbing degree of illness. The possibility that inflammatory changes in the ring may precipitate symptoms has already been referred to.

The study of the cases found incidentally after death from other causes, although interesting from the embryologic and pathologic points of view, does not illumine the clinical aspects of the condition as does the study of the ten cases recognized and treated as clinical problems. These ten cases, analyzed in Table I, present interesting aspects for discussion.

When symptoms occur they are, for the most part, those of duodenal obstruction. The picture may be complicated by the presence of the symptoms of an associated ulcer, including hematemesis. In one instance[6] the symptoms were those of an acute abdominal condition, later proven to be acute hemorrhagic pancreatitis involving the ring.

Diagnosis.—It is obvious that a diagnosis of annular pancreas cannot be made on clinical data alone. Of five cases examined roentgenologically before operation with the use of contrast material (Cases 5, 7, 8, 9, 10), the diagnosis was not made in four by the roentgenologist, and was originally missed in the fifth (Case 10). In view of the roentgenographic appearance of the lesion (Fig. 1), it would seem that careful roentgenologic examination of the duodenum in all cases of partial obstruction of the descending portion should permit a presumptive diagnosis in at least some instances, or, if not a presumptive diagnosis, at least the mention of annular pancreas among the etiologic possibilities. The failure to diagnose the disease stems from the failure to consider it, which, in turn, is caused by its apparent extreme rarity.

The diagnostic record of the surgeons who have operated for symptoms arising from the disease is not good. In three out of ten cases (Table I) the surgeons missed the condition at operation, though searching for the cause of obstructive symptoms, and in a fourth, under more difficult circumstances, the operator[6] recognized only the presence of retroperitoneal hemorrhage. In our personal experience the demonstration of the ring did not occur until considerable dissection in the region of the pancreas and duodenum had been carried out. It is possible that a number of cases have been missed through failure of the surgeon to remember that annular pancreas occurs.

This disease will probably remain difficult to diagnose roentgenologically and to be easily missed on exploration. It is safe to affirm, however, that the syndrome of chronic duodenal ileus, supplemented by corroborative roentgenographic evidence of obstruction, which also reveals a smooth niche constricting the second portion of the duodenum from its dextral aspect, should make possible, at times, a correct preoperative diagnosis. It must be remembered that chronic stenosing ulcer of the descending portion of the duodenum may present roentgenographic appearances indistinguishable from the outline described. Certainly, when operating for chronic duodenal ileus, the surgeon should thoroughly expose the anterior and lateral surfaces of the duodenum as far distally as the beginning of the third portion, mobilizing the transverse colon if necessary.

Treatment.—The treatment of the condition, when necessary, is obviously surgical. Two methods of attack seem more or less logical, namely, indirect methods such as posterior gastro-enterostomy or duodenojejunostomy, and direct methods such as division or partial resection of the ring with or without a plastic procedure upon the constricted duodenum. Of these, all but duodenojejunostomy have actually been empoyed on treated cases (Table I).

The most popular operation has been posterior gastro-enterostomy, the value of which is hard to judge from the results. Of five cases treated by this operation (Cases 1, 2, 4, 8, 9), three died postoperatively from respiratory infections. In one case (Case 1), the most important cause of obstruction was a congenital atresia of the duodenum beginning at the pylorus, for

which gastro-enterostomy is, of course, a logical procedure. The complete recovery in this case is, therefore, no evidence of the value of the operation for obstruction in the second portion of the duodenum. In the fifth instance (Case 9), recovery followed gastro-enterostomy, but here an additional, not particularly logical, procedure was also carried out. The surgeon, having opened the first portion of the duodenum longitudinally in establishing the diagnosis, closed it in the same direction with care to narrow its lumen to a degree approaching the normal.

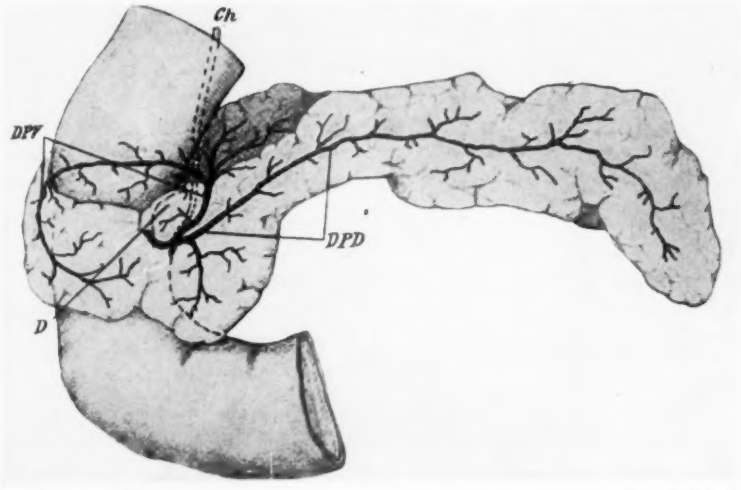

FIG. 5.—Diagram of typical duct anatomy of annular pancreas (from Cords[12]). The posterior portion of the duct of the ring has been drawn as though it passed anterior to the duodenum. The site of election for division of the ring is anterior, near the origin of its duct.

Partial resection of the ring has been employed in two cases with complete recovery in one instance and the probable persistence of symptoms in the other (Cases 3 and 10). Simple division of the ring has been followed by complete recovery in one case, complicated by the occurrence of an intra-abdominal abscess requiring drainage, which, in turn, was followed by a pancreatic fistula of alarming severity (Case 5). In one case, division of the ring was combined with a Heineke-Mikulicz plastic on the constricted duodenum, necessitated by failure of the constriction to unfold following release (Case 7). In this case a small pancreatic fistula closed spontaneously and complete recovery followed.

In general, direct attacks on the site of constriction are more appealing than indirect attempts to by-pass the obstruction. The recognized failure of gastro-enterostomy to cure cases of chronic duodenal ileus when the obstruction is at the ligament of Treitz would lead to the prediction that failure to relieve symptoms might follow the employment of this operation in annular pancreas. The evaluation of the optimum method demands a critical review of the mortality, as well as the complications and results. Four deaths occurred in the series, three following gastro-enterostomy and one as the result of an advanced acute hemorrhagic pancreatitis in which no

attempt was made to relieve obstruction. This high mortality is not interpreted as condemning the traditionally safe operation of gastro-enterostomy. More significant perhaps is the absence of mortality in four cases of direct attack on the ring, which is a simple, easily performed procedure, offering no particular hazards aside from possible pancreatic complications. The danger of pancreatic fistula, however, is real; it occurred in two instances out of four. Howard's[5] experience with this complication, notwithstanding the ultimate recovery of his patient, led him to advise duodenojejunostomy in place of direct attack, and Zech,[7] also the victim of fistula, offered the same advice. Truelsen[9] fears not only fistula but also pancreatic necrosis and, therefore, advises either gastro-enterostomy or duodenojejunostomy. As already stated, the latter operation has never been tested in this condition. It may be pointed out, however, that the anatomic relationships following this operation, particularly in relation to gravity drainage, would be quite different when performed in the first portion of the duodenum than when performed, classically, in the third portion. Furthermore, damage to the common bile duct is a danger of duodenojejunostomy at this level.

Although pancreatic fistula may occur following division or resection of the ring, attention to the anatomy of the annular duct suggests the possibility of minimizing the chance of its occurrence. It will be remembered that the duct originates with great constancy near the head of the pancreas anteriorly (Fig. 5). It is obvious, therefore, that the site of election for division is anterior, as near to the head of the pancreas as the safety of the pancreaticoduodenal vessels will permit; at this level the duct may be entirely avoided and, at the worst, will be cut across as a small twig at its origin. The danger of a postoperative pancreatic fistula should thereby be less than if the ring were divided further to the right, distal to any considerable bulk of secreting pancreatic tissue. Careful closure of the cut surface of the ring with interrupted fine silk sutures, according to the modern practice in pancreatic resection, is an added safeguard.

To summarize the available therapeutic data, there has been only one cure following gastro-enterostomy alone, in a case in which the obstruction was not primarily due to annular pancreas, and one cure following gastro-enterostomy combined with duodenorrhaphy. Of four direct attacks on the ring, three were followed by complete cure and one by indefinite persistent symptoms. The score is apparently slightly in favor of the division of the ring but the figures are too meager to warrant a positive opinion. One can at least state, on the credit side, that attack on the ring seems logical and that it has not resulted fatally and has effected more cures than failures. On the debit side, the danger of fistula is present.

There seems to be justification, therefore, for tentatively advocating the following operative procedures: (1) Exposure of the annula and careful dissection to separate it from the duodenum. (2) Division of the ring as far to the left anteriorly as possible. (3) Resection of a sufficient portion of the ring toward the right and posteriorly to ensure adequate release of the duodenum. (4) If there is not complete expansion of the constricted

bowel, longitudinal incision of the stricture with transverse closure after the method of Zech.[7] (5) Ligation of presenting ducts in the cut surfaces of the pancreatic ring, followed by careful closure with interrupted sutures of fine silk. (6) Closure of the abdomen without drainage.

CONCLUSIONS

Annular pancreas is in some instances a disease of definite clinical significance, demanding surgical treatment when symptoms are present. The results of such treatment to date are encouraging. The reports of additional surgically treated cases are urgently needed in order to evaluate the proper therapeutic approach.

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EFFECT OF REMOVAL OF MALIGNANT THYMIC TUMOR IN A CASE OF MYASTHENIA GRAVIS*

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The frequent association of thymic abnormalities with myasthenia gravis has been noted by an increasing number of observers, and detailed information concerning this relationship has been given recently by Blalock, Mason, Morgan, and Riven,[1] Miller,[2] Aronson,[3] and others. Tabulation of all lesions of the thymus found in patients with myasthenia gravis was begun in 1917 by Bell,[4] who collected 56 cases of myasthenia gravis between 1901–1917, in which autopsies or operations had been performed, and in 27 of these thymic lesions were found. In 1935, Norris[5] reported the autopsy findings

Table I

Case No.	Year	Author	Patient Age	Patient Sex	Thymus Enlarged or Persistent	Thymus Tumor
		Symmers[6]				7x5x3 cm.
55	1932	(Case 23)	56	Male		Perithelioma
56	1936	Meister[7]	34	Male		Lympho-epithelioma, with metastases to pleura
57	1939	Leriche & Jung[8]				Tumor
58	1940	Miller[2]	35	Male	7x3x1.5 cm. each lobe. 60 Gm.	
59	1940	Miller[2]	45	Male	6x6x1 cm. 30 Gm.	
60	1940	Miller[2]	27	Female		2x1.5x1 cm. Encapsulated
61	1940	Miller[2]	34	Male		5x3x6 cm., 70 Gm. Encapsulated
62	1941	Campbell[9]				Tumor—Operation—Death
63	1941	Campbell[9]				Tumor—Operation—Improvement
64	1941	Aronson[3]				5.3x5x1.8 cm., 16.6 Gm.
65	1941	Blalock, *et al.*[10]	33	Male	X	
66	1941	Blalock, *et al.*[10]	28	Female	X	
67	1941	Blalock, *et al.*[10]	22	Female	Rt: 9x2.5x0.8 cm. L: 15x2.5x0.8 cm.	
68	1941	Blalock, *et al.*[10]	39	Female	Rt: 9x3x0.8 cm. L: 15.2x2x0.5 cm.	
69	1941	Blalock, *et al.*[10]	30	Female	Rt: 8x2.5x0.8 cm. L: 8x2.5x0.8 cm.	L.U. pole: 9x1x0.8 cm.
70	1941	Blalock, *et al.*[10]	34	Female	12x2.5x8 cm.	
71	1939	Duvoir, *et al.*[11]	37	Female		6x4x2.5 cm., 35 Gm. Thymocytoma—benign

Mention should be made of three cases cited by Meister,[7] in two of which the diagnosis of myasthenia gravis was in question, and in the third, the origin of the tumor was doubtful:

(1) Matras and Priesel: White, male, age 56, had ptosis of both eyelids, and disturbance of speech. At autopsy, a benign lympho-epithelioma of the thymus was discovered.

(2) Matras and Priesel: White, male, age 35, died following operation for removal of mediastinal tumor which proved to be an epithelioma of the thymus. Six months before this, the patient suffered with extremely rapid fatigability, but myasthenia gravis was not considered.

(3) Mann, L.: White, female, age 41, with history of myasthenia gravis for several years. At autopsy a tumor was found in the posterior mediastinum which was considered to be thymic in origin by two other investigators (Gold and Meister).

in four cases of myasthenia gravis, in two of which thymic tumors were found. He collected five additional cases, bringing the total to 35 instances of thymic

* Read before The Southern Surgical Association, Pinehurst, N. C., December 9–11, 1941.

lesions found in 80 autopsies and operations in myasthenia gravis. This tabulation was continued by Blalock, Mason, Morgan, and Riven,[1] in 1939, who added 18 cases of myasthenia gravis with thymic lesions proven by autopsy or operation, and to this list we have added 17 cases, including the series of six cases reported in 1941 by Blalock, Harvey, Ford, and Lilienthal[10] (Table I). Thus, in a total of 129 autopsies and operations performed in cases of myasthenia gravis, thymic lesions in the form of persistence, enlargements, or tumors have been found in 71 instances, or 55.04 per cent. Such consistent findings in over 50 per cent of myasthenics would indicate, without question, some intimate connection between such thymic lesions and the disease process itself.

During the past five years the number of proven instances of the association of thymic pathology with myasthenia gravis has doubled, indicating the significance of Norris'[5] statement that "pathologic changes may be found in cases of myasthenia gravis in direct ratio to the care with which they are sought." This presents the possibility of abnormal changes in thymic function being present in all cases of myasthenia gravis, and adds to the necessity of close investigation of such function in every patient with this disease.

To date, remarkably few attempts have been made to influence the course of myasthenia gravis by surgical methods, and these have been described by Blalock, Harvey, Ford, and Lilienthal.[10] Including a personal case, they recorded the details of eight operations performed upon myasthenics, five of which were done for removal of enlarged or persistent thymus. With the exception of Blalock's case, the results of these operations could hardly be called encouraging, since there were three postoperative deaths, and little or no evidence of improvement of the myasthenic status in the other five. The operative procedure used in the nontumor group might be criticized on the basis of incompleteness, since only neck incisions were made and the anterior mediastinum probably was not adequately exposed. Blalock's case represents the first and only report of a cure of myasthenia gravis, and this was accomplished by the removal of a benign thymic tumor in a patient rapidly declining with the disease who had had all of the various medical measures employed as well as roentgenotherapy. The marked clinical improvement of this patient has been nothing short of spectacular, since she has remained free from all evidences of the disease for five and one-half years. So far as can be determined, a remission of this duration has not been produced by medicinal or roentgenotherapy in a patient in whom the disease had reached such a severe state.

During the past summer, Blalock, Harvey, Ford, and Lilienthal[10] have advanced the possibility of the potential benefits from surgical intervention in cases of myasthenia gravis by performing thymectomies upon a series of six patients in various stages of the disease. Postulating the similarity of the symptoms of myasthenia gravis with the effects of curare poisoning, they suggested that some particular tissues of the body might produce a similar substance. Since the thymus is the site of pathologic changes in such a large

percentage of myasthenics, they reasoned that such an abnormal secretion might originate there, and, therefore, suggested exploration of the thymic region. Perhaps insufficient time has elapsed since these operations were performed to evaluate the results without bias, but the definite and striking "improvement that has taken place in most of the patients indicates that the thymus is concerned directly in the pathogenesis of the disease."[10]

The type of lesion found in the thymus in the 71 autopsies and operations was noted to be an enlargement or persistence in 30 instances, and a definite tumor was found in 41 instances. Microscopically, the thymic remnants presented a picture typical of simple hyperplasia and this term has been used in many descriptions. The tumors of the thymus present a more difficult problem of classification because of uncertainty regarding the origin of certain cell elements of the thymus. Also, confusion has arisen over what tumors found in the mediastinum might properly be termed true thymic neoplasms, but most authorities agree that this can be determined on a basis of (a) location, (b) shape, (c) morphology, and, according to Foot,[12] (d) failure to invade bone, (e) tendency to spread by extension to the surrounding pleura and pericardium, and (f) failure to metastasize below the diaphragm. Of the 41 instances of thymic tumors found at autopsy or operation, 37 were described as benign thymomata, and four were classified as malignant tumors. The four malignant tumors were discovered at autopsy.

Case Report.—J. B. G. W., white, male, age 52, was seen in consultation, July 30, 1941, with Dr. H. Ansley Seaman, of Waycross, Ga., in regard to the treatment of a tumor in the anterior mediastinum associated with myasthenia gravis. The first symptoms of myasthenia gravis appeared in September, 1939, with development of marked drooping of the left eyelid and weakness of the muscles on the left side of the face. He also noted slight weakness in swallowing and talking, and consulted a rhinolaryngologist who found no definite cause. These symptoms persisted for six weeks. In December, 1939, he suffered an attack of acute appendicitis which was treated by operation and followed by uneventful convalescence.

The next exacerbation occurred one year later and lasted about one month. His jaws and tongue became so tired that he could scarcely talk. In January, 1941, without fully recovering from the former attack, the patient became acutely ill with an upper respiratory infection (influenza) which lasted for ten days. Following this, all symptoms of myasthenia gravis became rapidly and progressively worse. Within a month he noted general weakness especially marked in the late afternoon and evening, and weakness of the tongue and throat muscles became so severe that the patient was able to talk for only a few minutes at a time. Weakness of jaw muscles prevented proper mastication of food and the patient lived on a liquid and soft diet.

March 28, 1941, he was seen by Dr. J. G. Lyerly, Jacksonville, Florida, who confirmed the diagnosis of myasthenia gravis and prescribed prostigmine, 15 mg., t.i.d. This was followed by definite improvement, which was described by the patient as "giving more strength to talk and swallow." He felt that he could not get along without the drug and discontinued it only after it caused severe gastric reaction (nausea, vomiting, and pain). Prostigmine was then discontinued and ephedrine substituted. This produced equally beneficial results and was not followed by troublesome side-effects.

Early in May, 1941, he was examined by Dr. William B. Porter, of Richmond, and Dr. Edwin Lehman, of Charlottesville, Virginia, while they were conducting postgraduate clinics in Waycross. In addition to the weakness of jaw and face muscles, they noted

the absence of the pharyngeal reflex and the diagnosis of myasthenia gravis was again confirmed. They suggested the possible association of a thymic tumor, and roentgenograms of the chest were made which revealed the presence of a sharply circumscribed, moderately dense shadow in the anterior mediastinum on the level with the third, fourth, and fifth costal cartilages (Figs. 1 and 2).

In June, 1941, the difficulty in swallowing became so severe that he was sent to the hospital for nasal feedings for a period of ten days. At this time food regurgitated into his nose, and mucus was so profuse that continuous suction was instituted to prevent choking. Examination of the spinal fluid was negative, and no sugar was found in the

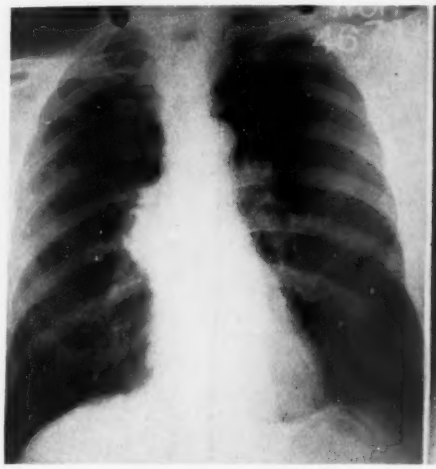

FIG. 1.—Roentgenogram, July 31, 1941, showing circumscribed shadow in anterior mediastinum.

FIG. 2.—Lateral view showing same shadow in anterior mediastinum.

urine. Blood count essentially normal. Blood pressure 138/80. There was no evidence of muscle atrophy or degeneration, and no changes in reflexes except the pharyngeal. No roentgenotherapy was given.

At the time of this examination, July 30, 1941, it was obvious that the disease was progressing rapidly, as evidenced by marked general weakness, which kept the patient in bed most of the time. Talking and swallowing were accomplished with extreme difficulty, since all symptoms were worse in the throat region. The question of removal of the tumor was discussed with the patient, who quickly made the decision since he felt that his condition "was hopeless unless something could be done."

Operation.—August 16, 1941, Ware County Hospital, Waycross, Ga. (Doctors Poer and Seaman): Anesthesia by local and block infiltration of novocain hydrochloride, 1 per cent. (Sodium pentothal, 2.5 per cent, given intravenously for last 20 minutes of operation—Dr. B. R. Bussell.) A slightly curved incision was made from the second to seventh rib level along the right margin of the sternum and carried through the soft tissues to the surface of the cartilages. The periosteum of the third, fourth, and fifth costal cartilages was divided for a distance of approximately 5 to 7 cm. and 4 cm. of each of these cartilages was removed. The right border of the sternum was removed with rongeurs for a distance of 1 cm. A greyish-yellow tumor, located in the thymic region of the anterior mediastinum, immediately came into view and could easily be separated from the sternum by blunt dissection with the index finger. The tumor was freed from the surrounding structures and found to lie on the pleura, pericardium, and large blood vessels. A small opening was accidentally made into the right pleural cavity which caused respiratory embarrassment for a few moments until closed with silk sutures.

The tumor was very soft and broke apart on removal, but was so well encapsulated that every portion could be identified and removed. The wound was closed in layers using interrupted sutures of black silk. Convalescence was complicated by two "sinking spells" accompanied by extreme cyanosis. Oxygen and prostigmine successfully relieved these symptoms.

Subsequent Course.—Before the patient left the hospital he was given two light roentgen ray treatments over the anterior mediastinum, but each of these was followed by evidence of shock and, therefore, they were discontinued. He was again given prostigmine for one week after operation and has taken ephedrine at irregular intervals

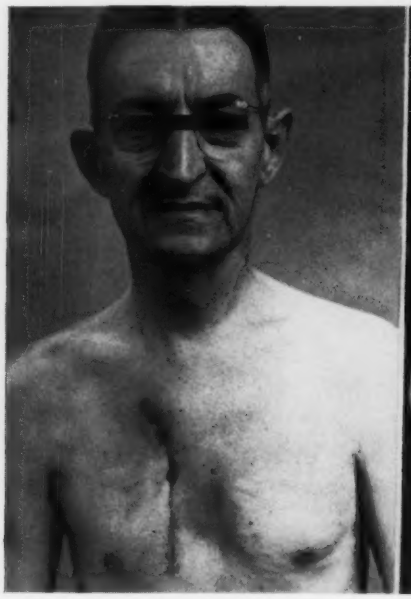

FIG. 3.—Photograph of the patient, December 5, 1941, showing scar of operation.

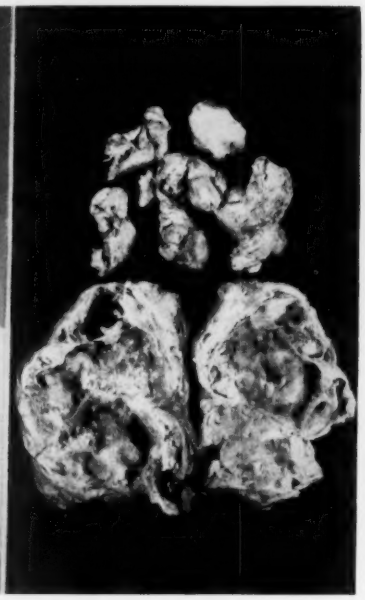

FIG. 4.—Photograph of gross specimen.

since. In November he developed acute pyelitis which confined him to bed for two weeks. He is now working regularly as a salesman, drives his own car, has no difficulty in swallowing, and can talk indefinitely without fatigue (Fig. 3).

Pathologic Examination.—Gross: Dr. Warren B. Matthews. "The specimen consists of a tumor, and parts of three surgically resected ribs. The rib pieces are each between 3 and 4 cm. in length and include the costochondral junction. These rib segments are grossly normal (Fig. 4).

"The tumor is a thin, fibrous shell filled with a putty-like greyish-yellow, crumbly material. It weighs 47.5 Gm. after formalin fixation, and measures externally 6.5x4.9x2.5 cm. The putty-like content is easily removed from the capsule, leaving a partly loculated interior. The fibrous capsule dips in, forming shelves that project into the cavity of the tumor. Nowhere is the material inside the capsule intimately adherent to the capsule. The tumor is uniform throughout in appearance. In places the capsule is so thin that it is almost translucent. The exterior of the mass is rough, and covered with stringy connective tissue fibers and bits of fat.

"*Microscopic:* Capsule: Three sections taken from the capsule of the tumor show that this is made of fibrous tissue with various degenerative changes. In places there are small granular amorphous calcifications. Zones of cholesterol and other lipoid deposits, with crystal clefts, are noted. These vary considerably in size. The connective

tissue is old and relatively avascular, containing relatively few nuclei. In the loose areolar tissue on the outside of the mass there are a number of small collections of lymphoid tissue. Some of these have a definitely follicular form. In only one place in these three capsule sections is the tumor adherent to the capsule.

"Tumor: All sections reveal a tumor made up of fairly large pale cells, apparently epidermoid, arranged in massive sheets (Fig. 5). Cellular outlines are poorly differentiated. In places the cells seem to assume no particular arrangement; in other places, the tumor cells are peritheliomatous, extending radially from the numerous thin-walled blood vessels present (Fig. 6). The nuclei are large and ovoid. They contain little

FIG. 5.—Photomicrograph showing general characteristics of the tumor made up of large pale cells, apparently epidermoid, arranged in massive sheets. Numerous fat-filled macrophages are noted. (×100)

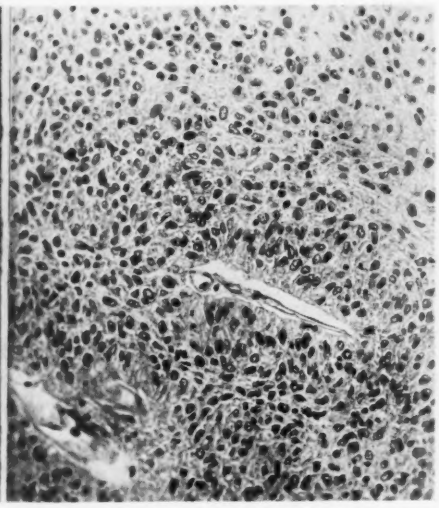

FIG. 6.—Photomicrograph of a section through a mass of tumor cells illustrating the perithelial arrangement noted in many places. (×200)

chromatin, and in most cases a single large nucleolus. There is some anaplasia although few mitoses are noted. From place to place, isolated amorphous deposits of material resembling keratin are noted. These are concentric and may be abortive Hassall's corpuscles. The fibrous stroma is scarce. Scattered throughout the tumor are a few lymphocytes and a few lipoid-filled endothelial leukocytes. *Pathologic Diagnosis:* Low grade carcinoma, probably thymic in origin."

DIAGNOSES OF CONSULTANT PATHOLOGISTS

Dr. Everett L. Bishop (Atlanta): Slide shows massive keratinization and lamellation with much cholesterin and lipoid structure. Calcification is present. Flattened cells show not many mitoses. There are occasional small cysts lined by cuboidal epithelium and various sized masses of hyaloid material. This is a dermoid or teratoid tumor of low malignancy (carcinoma) without definitely designating the point of origin, although some parts suggest thymus.

Dr. Sam Blackman (Johns Hopkins Hospital): The tumor is made up of sheets of epithelial-like cells which contain a considerable amount of pale cytoplasm and large ovoid nuclei with little chromatin and a single large nucleolus. The cells have a definite and characteristic lobular arrangement and in places they seem to extend radially from the numerous thin-walled endothelial lined vascular channels. Scattered among the epithelial cells there are lymphocytes. Few concentric masses of hyalinized material are

found which appear to arise from the epithelial cells of the tumor and closely resemble Hassall's corpuscles. The tumor cells show some anaplasia but mitoses are not frequent. The picture is typical of the so-called carcinomata of the thymus and is relatively benign but tends to metastasize in the late stages.

Dr. N. Chandler Foot (New York Hospital): The tumor is composed of thymic reticulum cells which are ectodermal and quasi-epithelial and not related to the ordinary reticulo-endothelium. It has a definitely perithelial arrangement of cells, sometimes rather strikingly epithelial in appearance. Abortive Hassall's bodies are to be found here and there. The tumor is definitely malignant of a type described by Symmers (perithelioma).

Dr. Douglas Symmers (Bellevue Hospital): There are numerous blood vessels in the growth and tumor cells are arranged around their long axes for a row or two, after which the growth of the cells becomes disorderly. I have not been able to trace any connection between the vascular wall and the origin of the tumor cells. However, the vascular wall is extremely thin in the great majority of instances and represents merely an endothelial-lined slit. The tumor is malignant—and probably highly malignant. If one insists upon giving it a name, I think that "perithelioma" or "perithelial sarcoma" would suffice.

Dr. Murray Copeland (Baltimore): The sections show marked hyperplasia and multiplicity of Hassall's corpuscles with only a moderate amount of lymphoid stroma. Consensus of opinion is that it is an unusual type of low-grade carcinoma of the thymus.

Discussion.—The difficulty of writing down a generally acceptable classification of thymic tumors has been mentioned. Ewing's[13] statement has been quoted frequently, to wit: "No group of tumors has more successfully resisted attempts at interpretation and classification than those of the thymus. The problems involved include those which have complicated the embryologic and histologic study of the gland, while added difficulties arise from the comparative rarity and considerable diversity of the tumors, and from the somewhat imperfect knowledge of the general pathology of the thymus." He classifies thymic tumors as carcinoma, lymphosarcoma, and granuloma (Hodgkin's disease). Symmers[6] has studied a fairly large group of autopsy specimens from cases with thymic and thymic-like growths and found two associated with myasthenia gravis. While objecting vigorously to the use of the term "thymoma," he suggests the classification: (1) perithelioma; (2) epithelioma; (3) lymphosarcoma; (4) spindle cell sarcoma; and (5) Hodgkin's granuloma.

Along with the difficulties that have arisen in the proper classification of thymic tumors, some confusion has been found to exist in regard to the cellular activity of such tumors, making the clear distinction of malignancy somewhat questionable in some cases. Bell[4] mentions this possibility in criticism of the case reported by Meggendorfer in 1908, when he stated that insufficient information was given in his microscopic description of the tumor. Two other instances of malignancy of the thymus associated with myasthenia gravis are the autopsy cases reported by Symmers[6] in 1932. He classified these as perithelioma and lymphosarcoma.

Meister,[7] in 1936, described the autopsy findings in a case of myasthenia gravis in which a nodular tumor was discovered in the anterior mediastinum, with metastases to the right parietal pleura. Two types of cells were found on microscopic examination, those resembling lymphocytes and others of

typical epithelial appearance which had undergone malignant change. In classifying this tumor as a lympho-epithelioma, he states his belief that many thymic tumors reported as carcinoma or sarcoma were in reality of this same type.

No record of an operation for the removal of a malignant thymic tumor has been found, and all information regarding tumors of this type has been gathered from autopsy reports.

CONCLUSION

The association of thymic lesions with cases of myasthenia gravis has been reviewed and 71 proven instances have been collected from the literature. During the past five years, over two-thirds of the cases of myasthenia gravis, in which the thymus was examined at autopsy or operation, were found to have definite pathologic changes in the thymus. This fact, plus the results obtained by removal of one thymic tumor and six thymic enlargements by Blalock, Harvey, Ford, and Lilienthal,[10] indicates that the thymus, definitely, is concerned with the etiology of myasthenia gravis.

The removal of a malignant tumor of the thymus in a case of myasthenia gravis is recorded. This, apparently, is the only case of this type that has been recorded during the life of the patient. The marked clinical improvement that has resulted adds to the growing evidence that the thymus is partly if not entirely responsible for the disease. This experience, plus that of Blalock and his collaborators, would indicate that every patient suffering with myasthenia gravis should be offered the possible benefits of removal of the thymus regardless of the presence of a definite tumor.

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DISCUSSION.—DR. JOSEPH E. J. KING (New York, N. Y.): I am not capable of discussing Doctor Poer's paper, but I wish to say that, at the last meeting of the New York State Medical Society, Doctor Campbell, of Albany,

reported a somewhat similar case, with successful removal of the tumor, and I shall be glad to send this report to Doctor Poer.

Dr. E. D. Churchill (Boston, Mass.): I have enjoyed this presentation greatly. It is a very important case to place on record. I am not so certain, as yet, what general conclusions can be drawn from it, because thymic surgery is still in a formative state.

I have had three patients in the last ten years in whom I, as a surgeon, made a clinical diagnosis of myasthenia gravis. All three had thymic tumors, shown roentgenographically. They were recommended to the hospital and studied by the neurologists, who know more than I do about myasthenia gravis. I was told that these patients did not have myasthenia gravis, much to my disappointment. Then I found that the neurologists have an exact, but empirical, definition of myasthenia gravis. It is a disease entity based on the response to injections of prostigmine. The patients I refer to did not meet this specific definition. Possibly they would have been labeled myasthenia gravis before the definition of the disease by the prostigmine test had been established.

What I am driving at is this: Myasthenia gravis is a syndrome without established etiology and without a universally recognized and accepted pathologic finding in the thymus. On the basis of the prostigmine reaction, a great majority of patients with this syndrome are now labeled true myasthenia gravis; a few of these have thymic tumors. Certain other patients with thymic tumors and similar symptoms, but not reacting to prostigmine, are not properly termed myasthenia gravis. The best recorded responses to thymus ablation—as in the case here recorded—are in those patients with demonstrable thymic tumors. To conclude that the thymus should be removed in cases of myasthenia gravis without tumor is a jump ahead of the evidence. In carefully selected cases, however, this operation may be justified for the compilation of further data.

Dr. Barney Brooks (Nashville, Tenn.): The patient reported from my clinic by Doctor Blalock, who showed such marked improvement of myasthenia gravis following the extirpation of a mediastinal tumor, showed a remarkable response to prostigmine over a long period prior to operation, and I do not believe I have ever seen a more dramatic effect of the drug than occurred in the use of prostigmine in Doctor Blalock's patient. At times the muscle exhaustion would become so great that artificial respiration would have to be resorted to, to keep the patient alive until the injection of prostigmine could be administered. Immediately after the injection, not only was the patient's respiration restored, but normal strength seemed to be immediately restored to all muscles of the body.

Dr. D. Henry Poer (Atlanta, Ga., closing): In reply to Doctor King, and in regard to Eldridge Campbell's two cases, they were included in Blalock's recent article and, therefore, have been tabulated in Table I. One of these patients died suddenly two days after operation, and the second is improved, but there has been persistence of the myasthenia gravis.

Doctor Churchill brought out some pertinent points regarding the association of myasthenia gravis and thymic tumors. The first of these concerns an accurate diagnosis of myasthenia gravis; in this group several diagnoses have been made on very meager evidence, such as weakness of one group of muscles and abnormal fatigability. Perhaps a syndrome of some of these same symptoms may also be associated with mediastinal tumors as suggested by Doctor Churchill. The diagnostic tests of Viets in which the reaction to prostigmine is measured, plus the quantitative studies of the state of neuromuscular con-

duction described by Harvey and Masland (cited by Blalock) have made it possible to establish the diagnosis of myasthenia gravis. In the case of the patient reported here, the diagnosis was made by a neurologist who observed the beneficial response to prostigmine.

The cases operated upon by Doctor Blalock during the past summer, in which the thymic remnants were removed, will be followed with much interest. Since remissions of varying duration are known to occur in this disease, we will have to wait some time before attempting to evaluate the end-results. My thought in presenting our case was to make us more conscious of the thymus in patients with this disease in the hope that more conclusive evidence of their relationship may be obtained.

SUCCESSFUL EXPERIMENTAL LIGATION AND DIVISION OF THE THORACIC AORTA*

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WE WISH TO REPORT a new method that we have used for successful ligation and division of the thoracic aorta. Doctor Halsted[1] nearly succeeded in occluding the vessel by external pressure, and both Doctor Reid[2] and Doctor Pearse[3] succeeded in blocking it by inserting foreign bodies into the lumen. Doctor Pearse[4] also reported successful occlusion after external application of a band of cellophane in 1940. It was of great interest to us that Doctor Halsted had been able to constrict completely any of the large blood vessels except the thoracic aorta. After careful reading of his very complete papers, it seemed to us that there were probably two reasons for his failure. First, the change in the caliber of the vessel had always been made very abrupt and, second, that it had usually been produced by a very unyielding substance, namely, an aluminum band. We, therefore, outlined a series of experiments in which the constriction was to be made in the form of an hourglass, using for the purpose materials that would give to a certain extent with the pulsation of the vessel. We later changed the form of the constriction to the shape of a funnel with the large end pointing toward the heart. In the early experiments preserved fascia lata was used, but Doctor Hewitt and I found, as other people had previously reported (Reid[2] and Pearse[4]), that this substance soon disintegrated and allowed the vessel to widen its lumen. We next tried a double layer of the best quality silk cloth, but this was not satisfactory because it tended to wrinkle up like an accordion and also caused too much local tissue reaction. In time, the vessel opened under the cloth, allowing pressure to be reestablished in the aorta below the band before collateral circulation had been established. In order to prevent this from happening, we conceived the idea of applying a section of ordinary stationer's rubber band over the silk band, as a second stage. Finally, after about two years' work with only one successful experiment, we abandoned all other materials in favor of rubber. It seemed best for several reasons: It could be easily molded to the desired shape by mattress sutures; it gave well with the pulsation of the vessel, and caused very little tissue reaction by comparison with the other materials. We soon found that it was necessary, no matter what the material used, to produce the constriction always in two and usually in three stages in order to keep the pressure above the bands high enough to produce sufficient collateral circulation. At first we waited six weeks to two months between operations, but found that this was too long because the vessel opened too widely. We then tried a series where a lapse of only two weeks was allowed, but found that

* Read before the Southern Surgical Association, Pinehurst, N. C., December 9–11, 1941.

this was too short a period because, although the pressure below the bands had not been reestablished, neither had the collateral circulation been sufficiently developed. We lost six animals from what we considered to be too tight an application of the second or third band, and six more when we tied and divided the vessel. We came to the final conclusion that three weeks was about the right interval between the first and second stages and that three to six weeks between the time of application of the second and third bands was most likely to be successful.

Our final technic is as follows: The animal, a dog, is given 0.25 gr. of morphia and anesthetized with ether supplied through an intratracheal tube with air pressure. The left side of the chest from about the middle of the scapula to the twelfth rib is shaved and cleaned up with two coats of 3.5 per cent iodine, which is removed in turn by the application of 70 per cent alcohol. The chest is opened in the midaxillary line of the fourth interspace. The ribs are retracted by a self-retaining retractor and the lung is held aside with a spatula. This gives good exposure to the descending portion of the arch and the upper portion of the thoracic aorta. The vessel is freed from the posterior chest wall by blunt dissection with a small curved clamp. Next, a strip of the best sheet rubber 1 Mm. thick and 1 cm. wide is drawn around the aorta just above the first intercostal artery. It is tightened in the shape of a rather wide-mouthed funnel by means of mattress sutures of silk. The first suture is placed so as to decrease the caliber of the vessel very little. Each successive one, however, is placed so as to make the band tighter, and the final one so that only a very faint thrill is felt below the band and the vessel wall seems flabby. The silk sutures are tied down tight in order to try to bury them in the rubber so that they will not come into direct contact with the vessel wall. The width of the band can be varied according to the size of the vessel. The rubber is boiled with the instruments for the same length of time. Two sutures of braided silk are used to appose the ribs, after the air has been expressed from the pleural cavity, by fully expanding the lungs with positive pressure through the intratracheal tube. The chest wall is then closed in layers with black silk. Three weeks later the chest is opened through the fifth interspace. If the pressure is found to have returned to the section of the aorta below the band, a second rubber band is applied in the same manner between the first and second intercostal arteries and tightened to the same degree as the first one and closure made in the same manner. If, however, pressure is found to be still very low, nothing is done at this time.

If a third stage is found to be necessary, about a month or six weeks is allowed to elapse depending upon how high the tension was found to be at the second stage, and a third band is placed one intercostal artery lower in the same manner as the first two.

A month or six weeks is again allowed to elapse before the chest is reopened, at which time the vessel is ligated just below the last band and again about 1 cm. distal to it, the ligatures being of doubled C silk. The section of the vessel between the ties is crushed with a Kelly clamp to promote fibrosis.

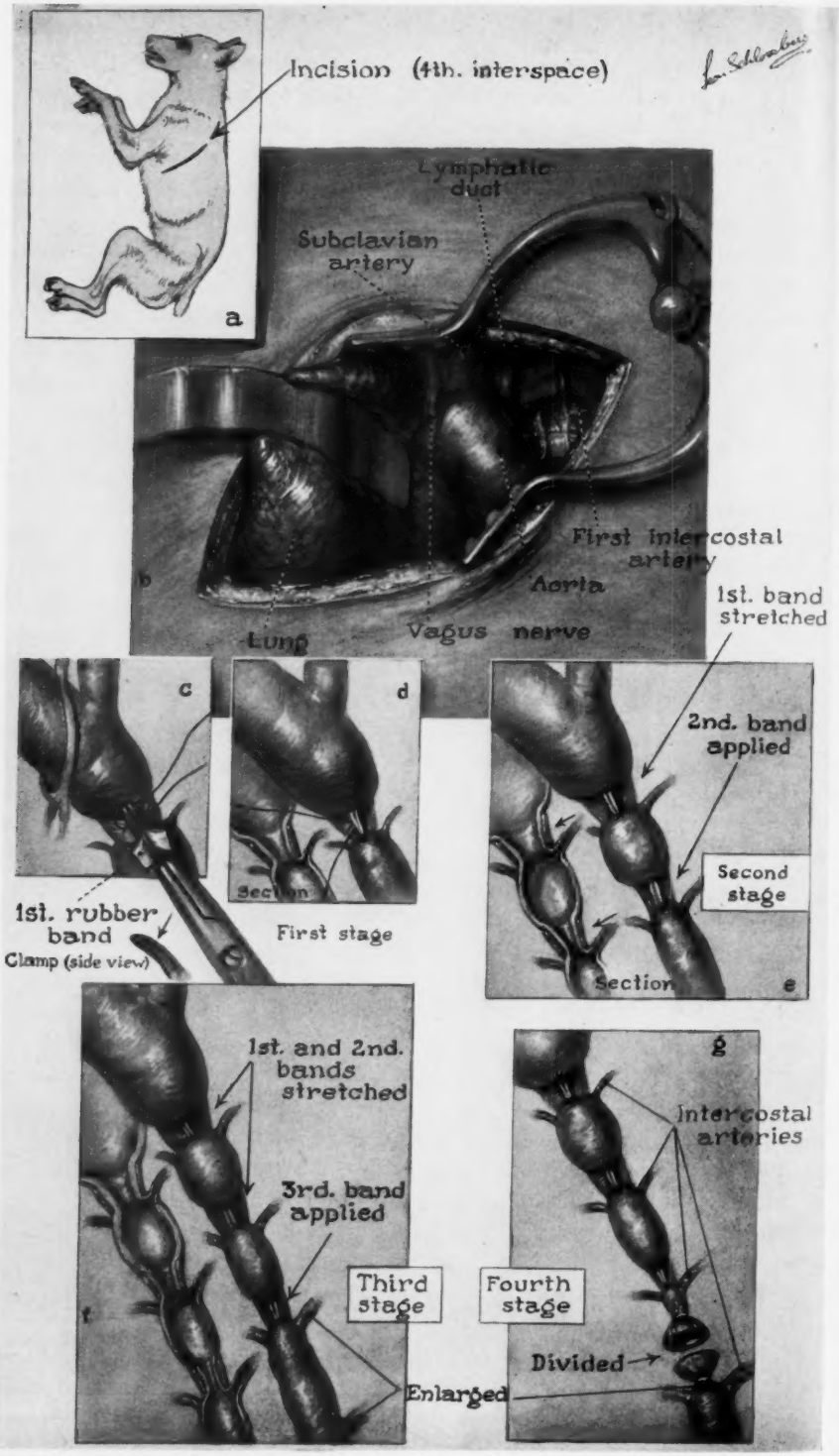

PLATE I.—Demonstrates technic of applying rubber bands. They are made of the best sheet rubber, 1 mm. thick and about 1 cm. wide, and tightened in the shape of a funnel by mattress sutures of silk. The ligation and division are shown as a single stage but in reality were usually done as separate steps. The intercostal vessels become greatly dilated below the most distal point of constriction.

Finally, time enough has to be allowed for the crushed segment to become fixed before dividing it, or else the cut ends have to be tied together to prevent retraction. Every time we attempted ligation and division in one step without tying the ends together the animals died, even though they could stand up and wag their tails immediately after they came out from under anesthesia. We feel that this was due to the fact that the ends of the aorta usually retracted well over an inch, which in turn probably caused angulation of the intercostal vessels. This angulation apparently disturbed the collateral circulation to such an extent that it became insufficient. We found this out by reviewing the notes on the first successful animal in which there had been considerable bleeding at the time the aorta was divided. This forced us to transfix the intercostals near the field of operation with sutures of silk which prevented the ends of the aorta from retracting. Plate I demonstrates in detail the various steps of the operative procedures.

The results of the whole group of experiments may be summarized as follows: During the course of the work, 75 dogs and four cats were used, and the chest was opened 162 times. Seventeen of the animals died from distemper, seven from empyema, 12 from what we consider to be insufficient collateral circulation, six from having the band drawn too tight, one from anesthesia, two from accidental death in a dog fight, four were sacrificed, and 28 died from hemorrhage due to the various types of bands cutting through the wall of the aorta. It can be readily seen that by far the commonest cause of death was hemorrhage. The first band cut through 14 times, the second band ten times, and the third band twice, and two animals died from secondary hemorrhage due to inadequate control of bleeding from collateral vessels. Only six animals of the whole series lived any appreciable time, and two of these had to be killed because of paralyses in the hind extremities, one after two and one-half months, and the other after six weeks. The remaining four would probably have lived indefinitely and, therefore, must be considered as successful experiments. The protocols for these four animals are presented in detail:

PROTOCOLS OF FOUR SUCCESSFUL EXPERIMENTS

Dog No. 16.—October 27, 1937: Grayish-black female, fairly large, solid color, given 0.25 gr. morphine hypodermically and anesthetized with intratracheal ether. Chest opened in fourth interspace and aorta, which was considerably larger than average, constricted in the usual manner by a band of doubled glove silk. When we had finished, the band did not feel tight enough, so it was further tightened by a tie of braided silk until a bare thrill could be felt. Constriction was made just below the arch and above the first intercostal. The dog stood the operation well.

November 24, 1937: Chest reopened, aorta below the tie was found to be still flabby and a thrill could be felt. Much more blood was going through than when the first constriction was made. Aorta again compressed by two ties of braided silk, one over the lower end of the silk band and one about 2 cm. below this, which were tied down until a bare thrill could be felt.

January 31, 1938: Aorta had returned to about the size it was on November 24. It was again constricted, this time by a rubber band placed between the two braided silk ties and tightened until the vessel wall was flabby and only a faint thrill could be felt.

March 16, 1938: Aorta still flabby and only a bare thrill was felt, but tension did seem a little higher than when noted on January 31. The heart seemed greatly dilated. Chest closed without doing anything to the aorta.

June 8, 1938: Aorta completely tied off with doubled braided silk just below the lowest point of constriction. Before the tie was made a faint thrill could be felt but tension in the vessel seemed very low. The animal stood the operation well and had some tone in both hind legs and also in the

tail immediately after operation. The animal did, however, seem to have some respiratory distress and the heart was huge, occupying about one-fourth of the thoracic cavity.

June 22, 1938: The animal regained the use of the hind legs within 48 hours, and has been active ever since.

May 10, 1939: Animal had been quite healthy during the past year. Chest reopened. The aorta was still rather flabby with no pulsation felt below the ligature, but a very faint thrill was made out, so blood was apparently leaking through the site of the tie to some extent. The heart did not seem to be greatly enlarged. The intercostal vessels were quite large and one was perforated during the closure of the chest wall, causing bleeding which was controlled only with great difficulty. The aorta was tied twice, once on the normal wall below the old tie and once about 1 cm. above this over the old scar tissue of the previous tie. The animal stood the operation well.

FIG. 1.—Roentgenogram of collateral circulation of Dog No. 16 after injection of modified Hill's mass. Aorta can be seen to be interrupted just below the arch and beginning again at about the level of the sixth intercostal. Most of the collateral goes through the internal mammary arteries.

May 15, 1940: Chest reexplored. Fairly good pulse in the aorta but no thrill, indicating that there was good collateral circulation but no leak through the point of previous occlusion. The intercostals were very large and a good pulsation was seen in them. Considerable bleeding was encountered in opening the chest wall but was controlled with little difficulty. The aorta was easily exposed, but after being freed a pair of intercostals were found to empty into the segment that was to be cut, so these were tied off first. The aorta was then divided between ligatures of doubled C silk. The ends did not retract because the mattress sutures used to tie the intercostals held the two cut ends together. The animal seemed to stand the operation very well.

October 1, 1940: Dog went blind during the summer, and the resident ophthalmologist said that this was due to bilateral retinal separation. She has seemed very well otherwise.

December 16, 1940: Kidney function test: 0.5 cc. of phenolphthalein introduced intravenously, 20 per cent in 30 minutes, 30 per cent in 60 minutes, total 50 per cent in one hour.

December 18, 1940: Liver function test: 5 mg. bromsulphalein per kilo introduced intravenously. Five minutes, 10 per cent; 30 minutes, 0 per cent.

May 19, 1941: Pressure in right carotid artery 190 Mm.Hg. Left femoral 157 Mm.Hg. (Pressures taken by puncturing artery with a small needle connected directly to a mercury manometer.)

July 28, 1941: Blood chemistry N.P.N. 38, chlorides (as sodium chloride) 468, sugar 68. Kidney function, phenolphthalein 30 minutes, 20 per cent; 60 minutes, 25 per cent; total 45 per cent.

July 30, 1941: Right carotid was moved up under skin so it could be easily used to determine blood pressure.

September 8, 1941: Liver function test: 5 minutes, 40 per cent; 30 minutes, 10 per cent. Blood chemistry N.P.N. 64, chlorides 514.8, sugar 76.

September 10, 1941: Pressure right carotid 182 Mm.Hg. Right femoral 142 Mm.Hg. Kidney function test: 30 minutes, 50 per cent; 60 minutes, 15 per cent; total 65 per cent.

September 29, 1941: Blood chemistry N.P.N. 29, chlorides 495, sugar 80.

October 1, 1941: Pressure right carotid 190 Mm.Hg. Pressure right femoral 140 Mm.Hg. Liver function test: 5 minutes, 30 per cent; 30 minutes, 10 per cent.

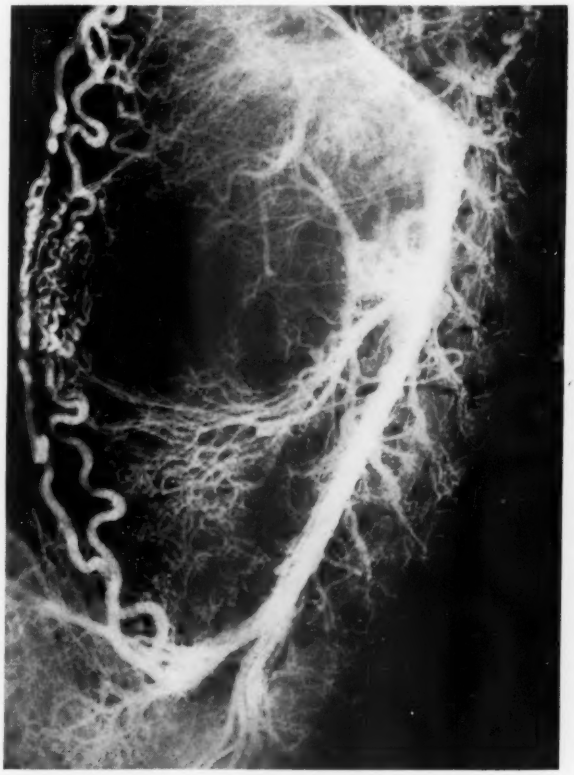

FIG. 2.—Shows the blood from the dilated internal mammary arteries continuing through the superior and inferior epigastric vessels back into the iliacs.

October 13, 1941: Dog killed to-day by injecting modified Hill's mass into the left carotid as she was bled from the right jugular vein, in order to demonstrate collateral circulation. Roentgenograms showed that most of the blood was carried by the internal mammary vessels and the phrenic artery into the intercostals below the site of the division back into the aorta and directly through the superior and inferior epigastric vessels into the iliacs. This collateral circulation is well demonstrated in Figures 1 and 2. The tissues looked grossly normal except for the liver, which showed some evidence of chronic passive congestion, and the aorta, which showed the changes so well described previously by Doctor Halsted[5] and Doctor Reid;[6] that is, a decided thickening of the vessel wall above the point of division, due principally to an increase in the muscle of the media, a replacement of the vessel wall by fibrous tissue under the bands, and a tendency of the vessel wall to thin out immediately below the point of division. The eyes were turned over to the Wilmer Institute for study.

November 24, 1941: Microscopic sections of the tissues merely confirmed the gross impression as shown in Figures 3 and 3A.

Dog No. 22.—January 29, 1939: Shaggy, long-haired, white and tan, male. The chest was opened through the fourth interspace. The aorta constricted just above the first intercostal by means of a rubber band until only a bare thrill could be felt and the vessel wall was flabby. The band was very narrow and it was felt that it might cut through.

FIG. 3.—Sections (A) and (B) are from Dog No. 30, and (C) and (D) from Dog No. 16. They illustrate the marked thickening that occurred in the media of the aorta above the point of division due to the sustained hypertension in the upper segment.

FIG. 3A.—(A) is a longitudinal section of the aorta wall of Dog No. 16 taken above the point of division, and (B) from below it. They show the same changes in the media as in Fig. 3. There is also complete replacement of the vessel wall by scar tissue where it has been compressed and ligated.

April 12, 1939: Chest wall infected; wound opened and silk removed, then loosely closed with catgut sutures.

May 15, 1939: Chest reopened through the fifth interspace. Since the vessel had opened until there was fair tension below the first band, a second rubber band was placed around the aorta between the first and second intercostals and tightened until only a very slight thrill could be felt.

June 28, 1939: Chest explored. There was still too much tension in the aorta, so a third band was placed two intercostals below the second one, and tightened to the usual degree.

August 21, 1939: Two of the previous wounds were infected and had to be opened so that the silk could be cleaned out and the wound closed with catgut.

October 11, 1939: Aorta doubly ligated with heavy braided silk, the first ligature being placed just below the last band and the second about 1 cm. below it. The portion of the vessel between the two ligatures was crushed with a clamp. The dog stood the procedure well and was able to walk as soon as he came out of the anesthesia.

October 16, 1939: Dog in good condition. Little if any weakness of hind legs.

May 13, 1940: Chest reopened. Aorta showed very faint pulse below site of ties and no thrill. The ties were so near the diaphragm that exposure was difficult. A dilated intercostal vessel was torn during the attempt to expose the field of operation and controlled only with considerable difficulty. However, the aorta was finally exposed and completely divided under direct vision after having been tied with doubled C silk. It did not retract because the mattress suture on the intercostal held the cut ends close together. The animal was in good condition postoperatively in spite of considerable loss of blood. He was able to wag his tail and stand up.

July 7, 1940: The dog had remained in good health, and it had been intended to make physiologic studies on the animal in the fall, but to-day he was found dead in the yard of the laboratory, having been killed in a dog fight. The tissues were so badly disintegrated that no attempt was made to get microscopic sections. Field of operation showed no hemorrhage or infection.

Dog No. 23.—February 6, 1939: Tiny white dog, male. The chest was opened through the left fourth interspace, and a band of rubber placed around the descending portion of the arch just above the first intercostal and drawn down with mattress sutures until the vessel wall below was flabby and only a very slight thrill could be felt.

April 17, 1939: Chest reopened; intercostals below previous band were greatly dilated—approximately three times normal. No thrill could be felt in the vessel and no pulse below the previous band, but tension seemed normal even when the vessel was completely compressed in the region of the band. A second rubber band was applied one intercostal below the first one, almost completely compressing the vessel, but tension still remained high. There must have been a large volume of blood entering the aorta below the first band by way of collateral vessels. The dog stood the operation well.

June 26, 1939: Chest explored. Very few adhesions were found. No thrill or pulse felt in the aorta below the compressing bands but tension did not seem to be as high as it was on April 17. Vessel doubly ligated one intercostal below point of compression. The upper ligature was of braided silk and the lower of doubled C silk. The ligatures were placed about 1 cm. apart and the wall of the aorta was crushed between them to promote fibrosis. The dog stood the operation well and had good tone in the rear extremities as soon as he woke up.

May 8, 1940: The dog has been in good health during the past year. Chest reopened. The intercostals were found to be greatly dilated and much bleeding was encountered in the intercostal muscles. No pulse could be felt in the aorta and no thrill below the tie. The area between previous points of ligature was found to be collapsed and felt fibrosed. Religated with doubled C silk just below previous ties and divided. A double ligature was placed on the lower end and a single on the upper end. Cut ends were not allowed to retract.

May 13, 1940: Dog ate a full meal on night of operation. Has no weakness of the legs or tail and has been in fine condition ever since.

July 7, 1940: Dog found dead, having been killed in dog fight. The tissues were so badly disintegrated that no attempt was made to get specimens for section. No physiologic studies had been made. Field of operation showed no hemorrhage or evidence of infection.

Dog No. 30.—January 27, 1941: Small, shaggy, gray male. Left side of chest opened through fourth interspace, and a band of rubber sheeting, 1 cm. wide, funneled around the aorta between the first and second intercostals and tightened until only a bare thrill could be felt and the vessel wall was flabby.

February 17, 1941: Chest reopened. The vessel showed a good thrill with fair tension below the band. The second band was placed two intercostals below the first and tightened to the usual degree.

April 28, 1941: Chest explored. Only a very faint thrill was felt in the aorta but pressure below the second band seemed fairly high. Vessel tied with doubled C silk just below the second band and again 1 cm. distally. The area between the ties was thoroughly crushed. The dog was able to walk and wag his tail as soon as the anesthesia wore off, but his hind legs seemed a little weak.

April 29, 1941: Hind legs are still weak but he can walk, though he wobbles considerably.

April 30, 1941: Strength of legs seems to have returned; also dog can wag his tail now. Bled for chemistry to-day. N.P.N. 52, sugar 86, chlorides 422.4.

May 5, 1941: Blood pressure right carotid 220 Mm.Hg., left femoral 100 Mm.Hg. Liver function test: 5 minutes, 20 per cent; 30 minutes, trace.

May 7, 1941: Kidney function test: 30 minutes, 17 per cent; 60 minutes, 40 per cent, total 57 per cent.

July 28, 1941: Blood chemistry, N.P.N. 40, chlorides 471, sugar 84.

July 30, 1941: Left carotid was moved up just beneath the skin.

September 8, 1941: Liver function test: 5 minutes, 30 per cent; 30 minutes, 0 per cent. Blood chemistry N.P.N. 48, chlorides 504.9, sugar 84.

September 10, 1941: Pressure left carotid 207 Mm.Hg., pressure right femoral 140 Mm.Hg. Kidney function test: 15 minutes, 40 per cent; 60 minutes, 12 per cent; total 52 per cent.

September 24, 1941: Examination of this dog's eyegrounds during the summer of 1941, by Doctor Walsh of the Wilmer Clinic, showed hemorrhage and exudates. The left eye showed a few absorbing exudates and both eyes showed many narrow vessels. The nerve heads were normal in color, and vision seemed normal.

FIG. 4.—Roentgenogram of collateral circulation of Dog No. 30 injected with modified Hill's mass. The aorta shows two areas of constriction and then complete interruption for about one inch. The constricted areas are at the sites of the first and second bands. The internal mammary arteries are again carrying most of the collateral blood, as in Dog No. 16. The posterior branch of one intercostal near the point of division is also very much dilated.

September 29, 1941: Blood chemistry N.P.N. 42, chlorides 488, sugar 85.

October 1, 1941: Pressure left carotid 218 Mm.Hg., pressure right femoral 148 Mm.Hg. Liver function test: 5 minutes, 10 per cent; 30 minutes, 0 per cent.

October 6, 1941: Chest reopened, very few adhesions found. The area of the aorta between the ties seemed calcified and when it was cut felt also as though it was. The lumen was obliterated. The cut ends were tied together by ligatures placed near the previous ties in order to prevent retraction and possible angulation of the intercostals. Dog stood the operation well and was up and walking around within an hour.

October 27, 1941: Animal sacrificed to-day by injecting modified Hill's mass into the left carotid. One hundred and fifty cc. of the solution were used, and the injection was made with a syringe with the animal under anesthesia while being bled from the right jugular vein. Two plain roentgenograms were taken and then stereoscopic films. No gross changes were noted in the organs except evidence of chronic passive congestion in the liver. The aorta above the constriction was greatly thickened but not as much as in Dog No. 16. The portion under the bands was replaced by scar tissue, and the section that was tied off was calcified, with obliteration of the lumen. The collateral circulation was the same as that in Dog No. 16, and is well demonstrated in Figure 4.

November 27, 1941: The microscopic sections showed nothing abnormal except that they confirmed the impressions gained by looking at the gross specimens of tissue, as demonstrated in Figure 5.

COMMENT

We feel that we have been able to demonstrate a new method which in, at least, a small percentage of cases makes it possible to tie and divide the thoracic aorta and still have the animal survive indefinitely in a normal state

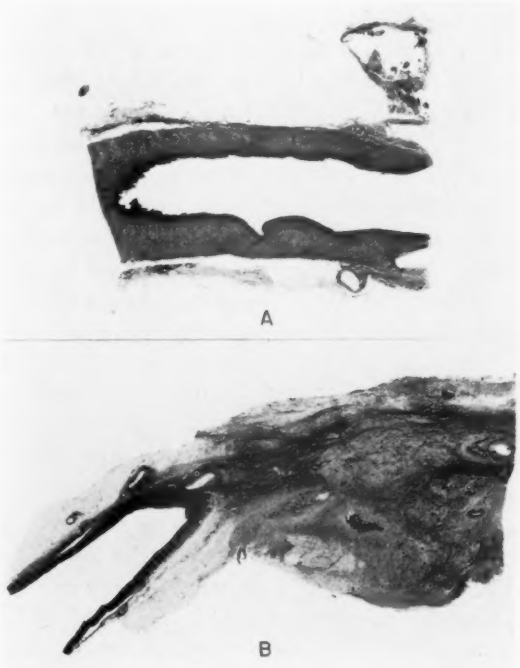

FIG. 5.—Section (A) was taken from the wall of the aorta of Dog No. 30 above the point of division, and Section (B) from below it. Both were cut longitudinally. They demonstrate the same changes in the vessel wall as were shown in Fig. 3A.

of health. The physiologic studies made on the two animals reported above, show that there was development of sufficient collateral circulation to allow normal function of the organs below the site of division of the aorta without any demonstrable microscopic changes, except evidence of some chronic passive congestion in the liver. However, the blood pressure above the site of division apparently remains very high for, at least, as long as three years, and may lead to changes in vision as demonstrated by the retinal separation and hemorrhage noted. Therefore, if this method was ever used on a human being this possible complication would have to be kept in mind. We doubt very much if it would be possible to apply a series of bands to the human aorta successfully because in cases of aneurysm, which would be about the only indication for its use, the vessel wall would probably be so diseased that it would be almost certain to be cut through. In instances in which the remaining portion of the vascular system is normal, this objection would not

apply. One band placed fairly close to the aneurysm might slow the circulation enough to produce thrombosis, which would probably be all that would be necessary. The method affords a very good means of studying the effect of hypertension on the heart and other structures above the point of division. It would also probably be very interesting to study the blood pressures below the point of constriction shortly after it was produced, in order to see whether it is low enough to cause disturbance in the function of the organs below the diaphragm. The pressure certainly seemed very low and yet the animals did not show any apparent disturbance of function. No physiologic studies were made early on any of the animals because we had no idea which ones would live and did not have time to study them all. We were not able to develop any certain means of determining just exactly when an animal would stand ligation of the aorta. This is well illustrated by the fact that 20 animals were carried to the point where we thought ligation would be safe, but only six actually survived it for any appreciable length of time, and two of these were paralyzed in the hind quarters. It might be that if we had carefully measured the pressure in the femoral artery throughout the course of the experiments we would have been able to tell for certain when sufficient collateral circulation had developed. If I were going to repeat the experiments, I would unquestionably do this. By using wide bands of best quality rubber we were able to produce collateral circulation of sufficient degree within three to four months. We were never able to get an animal to survive after dividing the aorta as a primary procedure even when there seemed to be sufficient circulation below the constrictions. We found that it was necessary to ligate the vessel in two separate places and to crush the wall between the ligatures in order to get complete occlusion, because a single tie would either cut through the vessel wall or else the lumen of the vessel would become widened after the ligature had cut down to the intima. We wish to stress again the fact that after the vessel is divided the cut ends must not be allowed to retract, because through angulation of the intercostals or some other derangement the collateral circulation is so embarrassed that death will result. This technic could be used on any large blood vessel in the body when it is the wish of the operator to produce good collateral circulation distally before he ties or divides it.

We wish to thank Dr. Rudolph Matas[7] for presenting the preliminary report on this work, and Drs. Mont Reid and Herman Pearse for their interest in it. The microscopic sections were reviewed by Dr. Arnold Rich, of the Department of Pathology, for which we are very grateful.

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DISCUSSION.—DR. HARVEY B. STONE (Baltimore, Md.): I do not know anything about this subject, but would like to say a word of approbation and appreciation of this perfectly beautiful, long-continued, difficult work just presented so sincerely and convincingly by Doctor Owings. I cannot help but feel that he has made a very real contribution to the whole question of the control of circulation by surgical means. Whether this particular procedure may be applicable to the human aorta or not, he has clearly designated a number of principles, and he has introduced at least one or two conceptions of the mechanism necessary to be observed in any such procedure. So far as I know, no one else has called attention to the fact that the division of an occluded vessel may defeat the purpose of the experiment by releasing the upper proximal stump and permitting kinking of the vessels that carry on the collateral circulation, and if there were no other contribution than this I think that would be very valuable.

I have been following his work for a number of years and can assure you there has never been a more honest and sincere and painstaking piece of scientific investigation.

DR. BARNEY BROOKS (Nashville, Tenn.): The experience of Doctor Gage demonstrates again the uncertainty of the obstruction of a large artery by ligation in continuity. In a case I reported some 20 years ago, in which the aorta was completely occluded, after ligation in continuity proximal to a large aortic aneurysm, I believe we were correct in ascribing the success of the ligation in apparent continuity to the fact that the ligation was not in reality in continuity, because in the dilatation of the aneurysmal sac, both common iliac arteries had been obliterated and we were, therefore, dealing with what amounted to a terminal aneurysm.

The paper of Doctor Owings is a beautiful demonstration of a quality, unfortunately, not frequently found among medical investigators, particularly surgeons. His paper is in sharp contrast to those frequently heard in which the results of operation are reported much too soon to be of lasting value. Doctor Owings has demonstrated remarkable ability to carry on a single experiment, not for hours, days or weeks, but for years. For this sort of investigation he is to be commended.

The fact that he found hypertension after ligation of the aorta is opposite to the results which we obtained and published several years ago. In our experiments, however, the ligature was placed distal to the renal arteries. In his experiments, the ligature is proximal to the renal arteries, and I wonder if the hypertension which developed was not in reality because of the influence upon the renal circulation, similar to that produced by the Goldblatt clamp. Also, I would like to point out that he spoke simply of "blood pressure." I should like to call attention to the fact that numerous investigators, particularly workers on shock and hypertension, apparently measure only mean or systolic pressure. One is not always sure which of these is meant, and in

reality "blood pressure" is only significant when both systolic and diastolic pressures are measured.

Dr. James C. Owings (Baltimore, Md., closing): In answer to Doctor Brooks' question, I wish to say that all the pressures reported were systolic. They were taken by inserting a small needle, connected directly to a mercury manometer, into the lumen of the vessel. It would have been better, of course, to have recorded systolic, diastolic, and mean pressures. If we do further work we shall obtain all three. The production of hypertension in the upper segment is probably on the basis that Doctor Brooks suggested, that is, due to anemia of the kidneys produced by constriction of the aorta, giving the same effect as Goldblatt obtained by pressure on the renal arteries. However, kidney function was normal and microscopic sections of the kidneys showed no change in the tissue in spite of the fact that the pressure in the upper segments was still high at the time the animals were sacrificed.

Doctor Prioleau asked what happened to the rubber bands. Nothing happens to them except that they tend to migrate through the wall of the aorta as the layers of the vessel wall are destroyed by pressure and are replaced by scar tissue around the outside of the band. If the scar tissue does not develop fast enough, the bands may cut through and cause the death of the animal by hemorrhage. The rubber maintains its elasticity.

Finally, it is well to remember that in ligating the aorta two ligatures must be used and applied some distance apart. The vessel wall between the ligatures must be crushed in order to promote thrombosis and later fibrosis. If this is not done the lumen of the vessel will be reestablished as the ligatures cause atrophy of the vessel wall.

Dr. Mims Gage (New Orleans, La., closing): I would like to congratulate Doctor Owings on his excellent scientific presentation. It is the first time that gradual occlusion, with subsequent obliteration, of the aorta has been accomplished in the experimental animal. However, I should like to make it very clear that one cannot compare the dog's aorta to the human aorta. The dog's aorta is only comparable in size to the external iliac artery of the human, which latter artery can be ligated with comparative safety. The thoracic aorta is different because vital function of both the kidneys and gastro-intestinal tract is dependent upon its potency. Therefore, sudden occlusion of the thoracic aorta by ligature usually ends in disaster, either at the site of the ligature, or more likely in complete suppression of functions of both kidney and intestinal tract.

By the method of gradual occlusion, as demonstrated by Doctor Owings, the functional capacity of the anatomic organs is maintained by the development of an adequate collateral circulation. I do not believe that sudden occlusion of the abdominal aorta by cotton tape will result in permanent obliteration of the lumen. All cases that have survived ligation with tape have demonstrated, both clinically and at autopsy, that the lumen has been partially restored. The aluminum band cannot be used on the human aorta for the purpose of either gradual or sudden occlusion because it will always cut through, resulting in fatal hemorrhage. Therefore, if we can gradually occlude the aorta to a narrow tube by the method presented by Doctor Owings, we then can ligate the diminished aorta with success. The aorta will then be permanently obliterated.

Doctor Matas recently told me that he thought Doctor Owings' method of gradual occlusion was one of the greatest surgical contributions to surgery of the thoracic aorta. As the method has not been tried on the human aorta, we will have to wait before passing judgment on its clinical applicability.

GAS GANGRENE*

REVIEW OF SEVENTY-ONE CASES

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IN DISCUSSING GAS GANGRENE, several variable factors must be considered. The incidence and, to a lesser extent, the virulence appear to vary with time and locality.

Gas gangrene was relatively unknown during the Civil War; and Keen[1] did not see a gas infection during his entire service. On the other hand, the trench warfare of World War I offered optimum conditions for the development of gas gangrene, and Taylor[2] demonstrated the Welch bacillus in 70 per cent of wounds cultured during this period. Thus far there have been few cases reported during the present war.

When we turn to civil life, we find this same variation in incidence in different parts of the country. While there has been a definite increase in gas gangrene during the past 15 years, probably due largely to the increased number of automobile accidents, this increase has been more evident along the Eastern seaboard than in the deep South or middle West. The State of Virginia is in the unenviable position of reporting more cases of civil gas gangrene than any other locality of comparable population.

In 1900, Welch[3] was able to collect only 46 cases of proven gas bacillus infections and 14 of these were reported abroad. During the past ten years almost twice this number of cases have been seen in the Medical College of Virginia Hospitals alone. In 1926, Bellevue Hospital[4] reported one case of gas gangrene for every 7,310 admissions. During the past decade, one out of every 1,342 admissions at the Medical College of Virginia Hospitals had gas gangrene on admission or developed it during the hospital stay. Newell,[5] of Chattanooga, on the other hand, found only five gas infections in more than 42,000 traumatic cases during the past 21 years. He suggests that "porous, sandy, hilly soil does not harbor organisms as does flat country." Whatever the cause, it is interesting to note that the incidence of gas gangrene at the University of Virginia Hospital is almost identical with that at the Medical College of Virginia.[6]

The reported mortality from this condition has been more constant. One thousand, three hundred and eighty-nine cases occurred in the American Expeditionary Force, with 674 deaths, a mortality of 48.5 per cent.[7]

Ghormley,[8] in 1935, reported 33 cases occurring at the Mayo Clinic, with a mortality of 42.5 per cent.

Callender[9] and his associates collected 109 cases encountered at the San Francisco Hospital from 1919 to 1936, with a mortality of 51.8 per cent. He also reported 12 subsequent cases treated with roentgenotherapy, with only

* Read before the Southern Surgical Association, Pinehurst, N. C., December 9–11, 1941.

one death, but stated he was omitting several other fatal cases from this latter series because of marked arteriosclerosis.

Maes[10] recently reviewed 73 cases of gas gangrene treated in the Charity Hospital in New Orleans during the past ten years, with a mortality of 38.4 per cent. During this same period 341 cases of tetanus were seen in the Charity Hospital. Tetanus is rarely seen in Virginia, and no instance of this infection occurred in conjunction with gas gangrene.

The lowest mortality reported was that of Kelly, Dowell, Russum and Colien,[11] who collected a series of 132 cases treated by roentgenotherapy, with only 15 deaths, a mortality of 11.3 per cent. A careful review of this article, however, shows that ten additional cases, mentioned at the onset, are not included in the final tabulation, and if they, too, were unfavorable cases, the mortality would be considerably increased.

A further drawback in this series was the method used in gathering this data. The 142 cases were reported by about 100 physicians, and thus represent an average of less than two cases per physician. This is hardly a fair basis of comparison. To digress further for a moment, a comparison should be made between the type of gas gangrene seen in Virginia and that reported in this article. Doctor Kelly states that a patient who receives roentgenotherapy during the first 24 hours after the infection is recognized as an "early case," and 100 per cent of these patients should recover. It has been our unpleasant experience to have patients die within less than 24 hours after the infection was recognized clinically. He also states that a patient with gas gangrene should receive two roentgen ray treatments daily for three or possibly five days, and that one who has not received this amount of radiation has not been properly treated. We have found that a patient who survives 72 hours is usually well along the road to recovery, for most of our fatalities occurred within the first three days. These facts are mentioned in order to bring out a point that has been raised by others, namely, that Doctor Kelly may be treating a less virulent type of gas gangrene in the middle West than that encountered in the East.

A source of error in comparing mortality following different types of treatment has been the tendency of some authors to omit certain cases from their tabulations. This is particularly noticeable when some special mode of therapy is advocated. It is not uncommon, for example, to find patients who were moribund on admission, who had preexisting gangrene, marked arteriosclerosis, diabetes or so-called "gas infections" omitted for the summary, and thus a misleading impression may be given concerning the actual mortality.

With this thought in mind, a study has been made of all cases of gas gangrene treated at the Medical College of Virginia Hospitals during the past ten years. This period, from January 1, 1931, through December 31, 1940, was chosen, as it coincides with the present methods of diagnosis and filing charts. All cases with a positive bacteriologic diagnosis of *C. welchii*, which also showed evidences of a gas infection, and all patients with unmis-

takable clinical or autopsy evidence of this condition, were included in this study.

A study of this type is misleading in that some of these patients died of the associated injuries or disease, and the gas infection was of secondary importance, or nonexistent, at the time of death. It would be more misleading, however, to attempt to separate these cases, and I believe the gross figures are of more worth in evaluating the various types of treatment.

Seventy-one cases of gas gangrene were treated at the Medical College of Virginia Hospitals, and 21 died, a mortality of 30.9 per cent. The number of cases has been remarkably constant—36 during the first five years, and 35 during the last five years. The mortality, however, has increased; only eight patients died during the first five years, whereas 14 died during the second corresponding period. This was an increase of 75 per cent, despite the employment of additional therapeutic measures during this latter period.

The treatment during this decade corresponded to that followed generally, with the exception that prophylactic perfringens antitoxin was probably given more freely here than elsewhere, and sulfanilamide was used locally very early at the Medical College of Virginia Hospitals.

In 1931, nine cases of gas gangrene of the extremities were treated, chiefly by amputation and without perfringens antitoxin; only one patient died, a mortality of 11 per cent.

During the next four years, a prophylactic dose of perfringens antitoxin was usually administered to the traumatic cases, and large doses of antitoxin were given therapeutically. Débridements were performed more frequently than amputations. Twenty-seven cases were treated, and seven died, a mortality of 26 per cent. In fairness to this method, it should be stated that four of these deaths followed gas gangrene originating in the trunk. If only the cases were included in which the gas gangrene originated in an extremity, the mortality would be exactly the same as in the first year of the tabulation, namely, 11 per cent.

During the past five years, larger prophylactic and therapeutic doses of perfringens antitoxin were given. Roentgenotherapy was utilized frequently both prophylactically and therapeutically, and during the past two years many of these cases received sulfanilamide locally and generally, in addition to the usual surgical measures of débridement and amputation. Despite the intensity of this treatment, the mortality has been distressingly high—35 cases were treated, with 14 deaths, a mortality of 40 per cent. Four of the five cases with involvement of the trunk died. Even if we omit these cases from our tabulation, the mortality from gas gangrene of the extremities was 33.3 per cent, or three times that of the corresponding infections during the first five-year period. A careful search was made in an effort to explain this high mortality. Some of these patients had associated injuries or disease, that virtually precluded their recovery, but this was also true in our earlier cases. A possible explanation, in part, is found in the age distribution in the two five-year series. Only two patients were over age 60 in the first

TABLE I

RÉSUMÉ OF CASES

Year	Patient	Race	Sex	Age	Cause	Operation	X-ray	Antitoxin	Culture	Days in Hosp.	Result
1931	H. S.	C.	M.	28	Electrical burn	Amputation	..	..	C. *welchii*	40	Imp.
'31	C. M.	C.	F.	52	Nail wound	Amputation	..	..	C. *welchii*	14	Imp.
'31	J. W.	C.	M.	54	Ulcer. Diabetic	Amputation	..	..	C. *welchii*	96	Imp.
'31	B. J.	C.	M.	34	Human bite	Amputation	..	..	....	14	Imp.
'31	B. S.	C.	M.	34	Shotgun wound	Amputation	..	..	C. *welchii*	14	Imp.
'31	N. C.	C.	M.	52	Comp. fracture	Amputation	..	..	....	2	Died
'31	H. C.	C.	M.	20	Shotgun wound	Débridement	..	..	C. *welchii*	58	Well
'31	W. T.	W.	M.	43	Crushing injury	Amputation	..	..	C. *welchii*	50	Imp.
'31	J. W.	C.	M.	49	Comp. fracture	Amputation	..	..	....	35	Imp.
1932	W. F.	C.	M.	24	Shotgun wound	Débridement	..	P & T	C. *welchii*	45	Well
'32	J. C.	W.	M.	13	Crushing injury	Débridement	..	P & T	C. *welchii*	48	Well
'32	C. M.	W.	M.	32	Comp. fracture	Amputation	..	T	....	28	Imp.
'32	B. B.	C.	F.	36	Tubo-ovarian abscess	Drainage	..	T	C. *welchii*	36	Died
1933	M. B.	C.	F.	6	Crushing injury	Débridement	..	P & T	C. *welchii*	21	Well
'33	J. H.	C.	M.	42	Shotgun wound	Débridement	..	P & T	C. *welchii*	55	Well
'33	J. L.	C.	M.	25	Stab wound	Débridement	..	T	C. *welchii*	94	Well
'33	N. T.	C.	M.	16	Comp. fracture	Débridement	..	T	C. *welchii*	195	Well
1934	R. B.	C.	M.	22	Comp. fracture	Amputation	..	P & T	C. *welchii*	82	Imp.
'34	J. W.	C.	M.	32	Shotgun wound	Débridement	..	P & T	C. *welchii*	54	Well
'34	J. M.	W.	M.	45	Shotgun wound	Débridement	..	T	C. *welchii*	44	Well
'34	E. C.	W.	M.	33	Crushing injury	Débridement	..	P & T	C. *welchii*	60	Well
'34	G. R.	W.	M.	47	Comp. fracture	Débridement	..	P & T	C. *welchii*	3	Died
'34	W. A.	C.	M.	5	Comp. fracture	Amputation	..	P & T	C. *welchii*	102	Imp.
'34	D. F.	C.	M.	20	Shotgun wound	Débridement	..	P & T	C. *welchii*	57	Well
'34	E. B.	C.	M.	10	Comp. fracture	Débridement	..	T	C. *welchii*	150	Well
'34	D. S.	C.	M.	48	Shotgun wound	Débridement	..	P & T	C. *welchii*	4	Died
'34	E. J.	C.	M.	28	Perforated ulcer	Incision and Drainage	..	T	C. *welchii*	7	Died
'34	M. L.	W.	F.	73	Diabetic gangrene	Post amputation	..	..	C. *welchii*	3	Died
'34	F. S.	C.	M.	39	Perforated appendix	Incision and drainage	..	T	C. *welchii*	5	Died
'34	B. T.	W.	M.	53	Embolic gangrene	Amputation	..	T	C. *welchii*	44	Imp.
1935	P. G.	W.	M.	60	Amputation for cancer	Débridement	..	T	C. *welchii*	35	Well
'35	J. H.	C.	M.	50	Crushing injury	Débridement	..	P & T	C. *welchii*	18	Well
'35	B. W.	W.	M.	21	Shotgun wound	Débridement	..	P & T	C. *welchii*	13	Well
'35	T. M.	C.	M.	65	Diabetic gangrene	Post amputation. Débridement	..	P	....	8	Died
'35	J. B.	C.	M.	16	Shotgun wound	Amputation	..	P & T	....	122	Imp.
'35	E. R.	C.	F.	36	Infected incision	Drainage	..	T	....	6	Died
1936	W. R.	C.	M.	19	Stab wound artery	Amputation	..	T	....	59	Imp.
'36	C. P.	W.	M.	24	Comp. fracture	Amputation	..	P & T	C. *welchii*	55	Imp.
'36	H. V.	W.	M.	40	Thrombosis artery	Amputation	..	T	....	17	Died
'36	S. T.	C.	M.	72	Shotgun wound	Amputation	..	P	....	24	Imp.
'36	T. C.	C.	M.	64	Amputation gangrene	Débridement	..	T	....	13	Died
'36	G. H.	W.	M.	49	Amputation. Buerger's	Reamputation	+	T	C. *welchii*	48	Imp.
'36	J. F.	C.	M.	32	Comp. fracture	Amputation	+	P & T	....	29	Imp.
'36	W. A.	C.	M.	35	Shotgun wound	Amputation	..	P & T	....	42	Imp.
1937	E. G.	C.	M.	10	Comp. fracture	Amputation	..	P & T	....	49	Imp.
'37	C. D.	W.	M.	22	Gun shot wound	Amputation	..	T	....	31	Imp.
'37	E. M.	C.	M.	26	Comp. fracture	Sulfanilamide. Débridement	+	P & T	....	59	Well

TABLE I (*Continued*)

Year	Patient	Race	Sex	Age	Cause	Operation	X-ray	Antitoxin	Culture	Days in Hosp.	Result
'37	C. B.	C.	M.	19	Traumatic amputation	Débridement	..	T	....	52	Imp.
'37	E. S.	W.	M.	34	Shotgun wound	Débridement	+	P & T	....	2	Died
1938	A. B.	C.	M.	67	Infected burns	Bilateral amputation	..	T	C. *welchii*	5	Died
'38	G. M.	W.	M.	62	Comp. fracture	Amputation	+	T	C. *welchii*	166	Imp.
'38	M. S.	C.	M.	22	Bilateral gangrene	Bilateral amputation	..	T	....	8	Died
'38	L. S.	W.	M.	20	Comp. fracture	Sulfanilamide. Débridement	..	P & T	C. *welchii*	3	Died
'38	J. B.	C.	M.	35	Shotgun wound	Sulfanilamide. Débridement	..	P & T	.....	6	Died
1939	E. G.	C.	M.	34	Comp. fracture	Amputation	+	P & T	C. *welchii*	15	Died
'39	T. S.	W.	M.	63	Comp. fracture	....	..	P	C. *welchii*	2	Died
'39	W. B.	C.	M.	17	Shotgun wound	Sulfanilamide. Débridement	+	P & T	....	117	Well
'39	W. W.	C.	M.	30	Comp fracture	Sulfanilamide. Drainage	+	P & T	C. *welchii*	190	Well
'39	C. H.	C.	M.	27	Perforated ulcer	Sulfanilamide	..	P	C. *welchii*	6	Died
'39	H. B.	C.	M.	17	Shotgun wound	Incision and drainage	+	P & T	C. *welchii*	10	Died
'39	L. P.	W.	M.	37	Comp. fracture	Amputation	+	P & T	C. *welchii*	102	Imp.
'39	G. C.	W.	F.	26	Comp. fracture	Sulfanilamide. Amputation	+	P & T	C. *welchii*	56	Imp.
'39	H. M.	W.	M.	37	Traumatic gangrene	Amputation.	+	T	....	153	Imp.
1940	L. W.	C.	F.	31	Traumatic gangrene	Amputation. Sulfanilamide	+	P & T	C. *welchii*	34	Imp.
'40	D. B.	W.	M.	45	Comp. fracture	Sulfanilamide. Amputation	+	P & T	C. *welchii*	77	Imp.
'40	N. P.	C.	M.	23	Crushing injury	Sulfanilamide	+	T	C. *welchii*	4	Died
'40	A. B.	W.	F.	65	Hypodermic	Débridement	+	T	C. *welchii*	35	Died
'40	H. C.	C.	M.	64	Bilateral gangrene	Amputation	+	T	C. *welchii*	2	Died
'40	L. F.	C.	M.	18	Comp. fracture	Sulfanilamide. Amputation	..	P & T	....	33	Imp.
'40	C. J.	W.	M.	16	Comp. fracture	Sulfanilamide. Débridement	+	P & T	C. *welchii*	70	Imp.
'40	E. B.	C.	M.	26	Shotgun wound	Sulfanilamide. Drainage	..	P & T	C. *welchii*	52	Imp.

KEY: P = Prophylactic.
T = Therapeutic.
Well = Recovery without loss of extremity.
Imp. = Recovery with loss of extremity.

series, while seven patients over age 60 were found in the second period. The mortality for all patients past age 60 was 77.7 per cent. A second, and more disturbing explanation may be that the introduction of chemotherapy in some instances may have beguiled the surgeon into a false sense of security and he may have relaxed, unconsciously, in his effort to perform a thorough débridement of recent wounds.

A study has been made of the various preventive and curative measures used in the treatment of gas gangrene at the Medical College of Virginia. The various types of treatment will, of necessity, be considered separately, although they were usually used in conjunction with other forms of therapy.

Thirty-seven patients who subsequently developed gas gangrene received perfringens antitoxin prophylactically—ten died, a mortality of 27 per cent.

Thirty-four patients who had not received perfringens antitoxin prophylactically developed gas gangrene, and 12 died, a mortality of 35.5 per cent. Superficially, this would appear to indicate that gas gangrene ran a milder course and was more amenable to treatment if antitoxin was given prior to the clinical onset of the infection. Two facts argue against this interpretation. The patient who did not receive perfringens antitoxin as a prophylactic measure was usually either admitted after the onset of gas gangrene or the possibility of gas gangrene was not considered until the infection was evident, and sometimes advanced. The patient who developed unsuspected gas gangrene, as a rule, had a serious associated condition, such as diabetes, a preexisting gangrene, or a perforation of the gastro-intestinal tract.

A second method of evaluating the value of perfringens antitoxin may be found in the various numbers of units given in this series. Nineteen patients were given the so-called prophylactic dose of perfringens antitoxin, which represented 1,000, 1,500, or 2,000 units, depending upon the maker and the method of standardization (average dose was 1,579 U.). The mortality in these cases was 26.3 per cent. On the theory that if a small prophylactic dose was beneficial, a larger dose should be more helpful, our routine was then changed and a therapeutic dose of 10,000 units, or more, was given as a prophylactic measure to 17 cases. Five patients also died in this series, a mortality of 29.4 per cent. In other words, the mortality was slightly higher after a large prophylactic dose than after a small one. Two patients received 30,000 units, or 15 times the recommended prophylactic dose, and both developed gas gangrene, with death in one case.

Unfortunately, data are not available concerning the total number of patients who received perfringens antitoxin prophylactically, in terms of the number who later developed gas gangrene, but the above figures arouse doubt as to the value of antitoxin as a preventive measure. Pursuing this thought further, it is hard to see how a massive infection could be cured by antitoxin given therapeutically if a prophylactic injection of antitoxin could not prevent the infection at its inception.

Fifty-seven patients received an average of 31,560 units of perfringens antitoxin therapeutically, and 17 died, a mortality of 30.9 per cent.

Twelve patients received sulfanilamide locally as a precautionary measure, or orally as a therapeutic procedure, and four died, or 33.3 per cent.

Eighteen patients received roentgenotherapy as a prophylactic and/or therapeutic measure, and six died, again, a mortality of 33.3 per cent. Encouraging, however, is the fact that 35 patients were given roentgenotherapy prophylactically who failed to develop gas gangrene.

The operative therapy fell naturally into two groups, namely, amputation of involved extremities, or débridement, with excision of infected muscle bundles. Thirty-six limbs were amputated with six deaths, with a mortality of 18.2 per cent. Twenty-eight débridements were undertaken, with eight deaths, a mortality of 28.5 per cent.

To summarize, the following prophylactic and therapeutic procedures were used in the treatment of gas gangrene, with the indicated mortality:

Roentgenotherapy (prophylactic and/or therapeutic)	33.3%
Therapeutic perfringens antitoxin	30.9%
Sulfanilamide (locally and/or generally)	30.8%
Prophylactic (10,000 U.) perfringens antitoxin	29.3%
Débridement	28.5%
Prophylactic (1,000–2,000 U.) perfringens antitoxin	26.3%
Amputation	18.2%

Despite this inconclusive evidence, we have felt it necessary to formulate a uniform method for treating these cases, and the following outline, based on our experience and that of others, has been evolved:

In addition to the usual care that all traumatic cases should receive, every case in which the deep fascia is penetrated is considered a potential gas bacillus infection and treated accordingly. This includes a painstaking clean-up with sterile water, green soap and shaving, followed by ether, iodine, and alcohol. The operative field is draped, and a purposeful débridement is undertaken. No nonessential tissue that has been exposed by the injury is permitted to remain. It is imperative that the full extent of the wound be determined and explored. The under surface of the extremity must be inspected for additional injuries or wounds of exit. All foreign material and devitalized bone is, of necessity, sought and removed. The original instruments are discarded.

Muscle removed from the wound should be cultured for gas organisms. I cannot leave this phase of the treatment without emphasizing again the importance of the débridement. Ultimate success or failure hinges more upon this than any other aspect of the therapy. A copious warm normal saline irrigation is then used, care being taken that all parts of the wound are flooded with solution. After ligating all bleeding points, 10 Gm. of sulfanilamide crystals are placed in the wound if the incision is to be closed. Twice this amount may be used if the incision is to be packed open. Correspondingly smaller amounts should be used in children. The decision as to whether the incision should be closed rests upon so many considerations that I shall only say that if the edges cannot be approximated without tension, or if a dead space remains, the wound is left open, with an abundant gauze pack. If a fracture is present or if the wound is near a joint, the part is immobilized by an adequate plaster encasement. Fifteen hundred units of tetanus antitoxin are injected. A prophylactic or therapeutic dose of perfringens antitoxin may be given, if the operator has faith in this agent. If there is any impairment of the circulation to the part, a sympathetic novocain injection should be given. Henry[12] does this routinely in all potential cases of gas gangrene.

As soon as possible, on the day of operation, a postoperative roentgenogram is taken. This checks the position of the fragments if a fracture is present, and serves as a standard for comparison when later roentgenograms are made to determine if gas is present in the tissues. A prophylactic roentgen

ray treatment, as outlined by Kelly,[11] should also be given to the involved area at this time. Twelve hours later, another film is made to determine if gas has increased in the damaged area, and a second prophylactic roentgen ray treatment should be given. A third roentgenogram, made 24 hours after the injury, will definitely determine if a gas infection is present. If this is negative, there is little likelihood that gas gangrene will occur. Six grams of sulfanilamide, or sulfathiazole, should be given daily for the first 48 or 72 hours during this probationary period. The clinical signs and symptoms meanwhile should not be neglected, and excessive pain, swelling, tachycardia, discoloration, or crepitus should point to a gas infection. The roentgenologic diagnosis, however, can and should be made before these changes are evident. If gas gangrene develops, an immmediate débridement, or open amputation, should be performed, depending upon the degree of involvement and the state of the circulation distal to the infection. Roentgenotherapy and the sulfonamides should be continued. An erythrocyte count and hemoglobin determination should be made daily, followed by blood transfusions as indicated, for these patients frequently develop a rapid and severe secondary anemia. An electrocardiogram should be made before the patient leaves the hospital, for severe myocardial damage has been reported following gas infection.

In the above treatment an attempt has been made to combine the best elements in our own experience with those suggestions, made by others, that seem to offer the greatest likelihood of success. While it is too early to draw any conclusions as to its ultimate worth, we feel encouraged and justified in continuing this method.

CONCLUSIONS

The incidence of gas gangrene continues high in Virginia, despite active measures directed toward its prevention.

No single agent or drug has proved specific in treating this condition.

In our experience perfringens antitoxin has been disappointing both prophylactically and therapeutically.

The introduction of the sulfonamides may have caused some operators to be less careful in their débridement of wounds and this, in part, may explain some of our recent failures in preventing and treating this condition.

In traumatic cases an early, painstaking débridement is of greater value than any other procedure in preventing gas gangrene.

We have been unable to evaluate the worth of prophylactic and therapeutic roentgenotherapy, but do feel that it is helpful as an early diagnostic measure.

A suggested method of treatment is offered.

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DISCUSSION.—DR. E. DUNBAR NEWELL (Chattanooga, Tenn.): I think this paper is very timely. In 1938, I read a paper on this subject before this Association, and at that time I said the reason I was doing so was because I had a case of gas gangrene, and I thought I was familiar with it at that time. After I had this case, I read the literature and found I knew nothing about it.

There are a few things to stress distinctly. The first is that the incidence of gas gangrene infection varies markedly in different localities. But that does not have anything to do with the present status, because we will most likely have a million men in other fields within a year, and we must consider that we will have gas gangrene infections following the soldiers. Treatment begins when you first see the patient. Personally, I do not believe the mortality should be more than 5 or 10 per cent, if adequate treatment is given at once—adequate débridement, proper handling of the wound, and immobilization of the wound at once. Prophylactic polyvalent antitoxin probably does some good, but do not depend on it. In a series from New Orleans, the mortality was less in the cases in which they gave prophylactic polyvalent antitoxin for three days in succession.

To me the most important factor is the early diagnosis of gas gangrene infection. That cannot be done by smears and cultures. In evacuation hospitals in France we found that practically all cultures showed the *C. welchii* and other organisms of that type. As a matter of fact, only 60 to 65 per cent of those cases developed gas gangrene. So positive cultures and smears do not mean anything.

It is important to make an early diagnosis, and you must be more alert and more suspicious in making this diagnosis than were our forces in Honolulu in the present emergency. The first thing you notice is pain at the site of the wound. When you have a patient with a severely contaminated wound and he develops pain suddenly, look at the dressings, and if there is a sweetish-sour odor, a distinctive odor, and the wound looks a little puffy, and the pulse is high in proportion to the temperature, then take a roentgenogram, and if you see some gas bubbles in the wound, it is your duty to suspect at once that you have a gas gangrene infection, and polyvalent antitoxin should be given every four to ten hours in large doses.

DR. MIMS GAGE (New Orleans, La.): I would like to ask Doctor Warthen if he has noted any seasonal variation in his cases of gas gangrene. In

New Orleans we have found the incidence to be higher in the winter months. This is due to the prevalence of wool clothing which harbors the spores of *C. welchii*. In 1923–1924 and in 1932 we found that all wool clothing and blankets contained the spores of *C. welchii*. The felt wads of shotgun shells also contained *C. welchii* spores in 100 per cent of those cultured. We were able to produce gas gangrene in the experimental animal (rabbit) by inserting pieces of wool cloth and pieces of wads from shotgun shells into the traumatized muscles of the rabbit's thigh. The production of gas in the tissues was followed by roentgenographic visualization. In a number of the animals the wound was ruptured by the gas pressure. Therefore, we have believed that bits of wool clothing and wadding from shotgun shells driven into muscle tissue were responsible for the development of gas gangrene in a high percentage of civil cases. This of course would be greatly augmented in war.

The development of gas bacillus infection is dependent upon the presence of devitalized muscle to act as a culture medium. Therefore, one must first have muscle injury resulting in devitalization of muscle tissue. This occurs when the blood supply has been destroyed to a certain portion or portions of a single muscle or a group of muscles. There are certain vulnerable areas in which there is only one blood supply to the muscles of the lower extremity—first, the calf muscles; next, the gluteal region; and third, the thigh. In these areas, if the main artery is severed, traumatized or segmentally becomes spastic, large areas of muscle tissue immediately become ischemic, and the gas bacillus readily and rapidly invades and produces massive gangrene.

If we can eliminate all devitalized muscle, we can prevent the development of gas gangrene. Therefore, I have taught for years that gas bacillus infection is a preventable disease. However, it is so only when the surgeon has a thorough knowledge and practical appreciability of débridement. A good débridement is certainly more difficult of execution than is gastrectomy or colectomy. If one fails to remove all devitalized muscle by débridement, then he has not performed a débridement and the development of gas gangrene frequently takes place.

The use of the sulfonamides in the wounds after débridement seems to act as a protective and preventive measure. I believe that its effect is mainly by producing internal washing away of contaminating anaerobic organisms and coffer-damming the tissue by cellular infiltration. This prevents tissue destruction by the toxins as well as invasion of the tissues by the organisms.

The use of roentgenotherapy is of no benefit as regards specific effect on the organisms of the *Clostridium* group, and I believe it is of no value in treatment of gas gangrene. I sincerely believe that with a thorough knowledge of the bacteriology of gas gangrene, the surgical principles of débridement, with mechanical cleansing from both without and from within, will, in the majority of cases, prevent the development of gas gangrene. If infection has occurred, then it can be minimized or stopped by both surgical excision and local chemotherapy. However, in those cases where many muscles are involved (group or massive gas gangrene), amputation will be the procedure of choice. We must not expect too much from chemotherapy and should never subjugate surgical principles to chemotherapy, but combine both in an intelligent manner.

Dr. W. O. Bullock (Lexington, Ky.): Referring to the paper given by Doctor Firor this morning, I noted that sulfasuxidine in the intestinal tract seemed to possess a selective action against anaerobic organisms. It is not improbable that this selective action may occur or may take place elsewhere

in the body against the anaerobic germs responsible for gas gangrene, and it may well be that in this drug we may have the answer to this distressing problem.

DR. HOWARD M. CLUTE (Boston, Mass.): Severe gas gangrene infections are most frequently seen in crushing injuries of the extremities. It is true, however, that infection with *C. welchii* has in rare instances followed every type of surgical operation on the abdomen. I have, in recent years, observed three cases; one patient had rupture of the liver with a simple fracture of the ribs, and died of overwhelming gas bacillus infection; the others followed cecostomy and large bowel resection. Each of these recovered following large doses of antitoxin.

It is well known that *C. welchii* inhabits the intestinal tract of most people. If obstruction of the bowel occurs, with the resultant tissue anoxemia, the stage is set for these organisms. It is astonishing that more such infections do not occur in patients with bowel obstruction.

I want to emphasize what Doctor Newell said, with particular reference to abdominal wounds. The successful treatment is largely dependent on early recognition and immediate treatment. The signs are rapid rise of pulse and temperature, and especially pain in the wound, a copper-red color of the skin, and gas in the tissues, which you can hear with the stethoscope as early as you can find it roentgenologically. Smears and cultures confirm the diagnosis, but while waiting for these, active treatment should be undertaken. With gas bacillus antitoxin alone, both our cases with infections of the abdominal wall recovered. I have no doubt that to-day we would give sulfanilamide, but we would use antitoxin as well. It seems to me that in gas bacillus infections more than in any other condition, the surgeon's diagnostic acumen is the important factor in determining the outcome.

DR. JULIAN K. QUATTLEBAUM (Savannah, Ga.): I wish to express my appreciation for the privilege of discussing Doctor Warthen's paper. It is my impression that the frequency and virulence of gas bacillus infection certainly varies in different localities. It is not an infrequent occurrence in our section of the country, as I have had some 20 private cases during the past 15 years. We are inclined to associate gas bacillus infection with severe injuries and much damage to muscle tissue. However, this infection can follow a very trivial injury, and in such cases it usually proves fatal.

I have had three cases which followed very minor injuries indeed. The first was a physician who, having misplaced his cuff link, attempted to pin his cuff and punctured his wrist with the pin. Almost immediately a severe infection occurred with great swelling of the arm, intense pain, fever and prostration. We did not recognize this as being a case of gas bacillus infection until the arm was opened a few days later, then the typical odor, bubbles of gas and extensive necrosis of muscle established the diagnosis. This case was interesting in that he had just taken a tub bath and his skin was cleaner than usual when the accident occurred. The patient refused amputation and the arm was thoroughly débrided, but he promptly died. It is unlikely that amputation of the arm would have saved him.

The second case was a man who dropped a stick of stove wood on his foot. He was wearing his shoe at the time and the skin on the dorsum of the foot was barely broken. Within six hours the man was desperately ill, with an area of necrosis, approximately 6 cm. in diameter, surrounding the area of the injury. The remainder of his foot was livid. A few hours later the entire foot was gangrenous and the process had spread above the ankle

joint. A midthigh amputation was performed, and death occurred less than 12 hours later.

The third case was a ten-year-old girl who was bitten high on the thigh by a red-bug. The mother attempted to remove the tiny bug with a needle. Twelve hours later this area was seminecrotic and the child was very ill. The infection spread rapidly, involving the vulva, lower abdominal wall and the right leg above the knee. Although massive doses of perfringens antitoxin were given and extensive débridement undertaken, the fatal outcome was not long delayed.

It is my opinion that cases of gas bacillus infection such as these are incurable from the beginning. Other cases respond to treatment and get well. I have seen the infection stopped promptly and recovery take place following a shoulder joint amputation, when the gangrenous process was within a few inches of the joint itself. At times the infection is limited to one muscle or a group of muscles, and is apparently confined by the muscle sheath, and can be cured by simply excising the involved muscles. No doubt the shock of amputation has contributed to the fatal outcome in some cases and, certainly, it will not always stop the advance of the infection. However, if the infection is in a limb so badly crushed or mangled as to greatly impair its usefulness should recovery be possible, I think immediate amputation is the treatment of choice. The stump should be left open and negative cultures should be obtained before secondary closure is attempted, as recurrence in the closed stump has occurred in my experience. Roentgenotherapy and the sulfonamide drugs have been used in the treatment of practically everything else, and may be of value in the therapy of gas bacillus infection. In this connection I am reminded of the man who, being notified of his mother-in-law's death, was asked to advise whether she should be embalmed, buried or cremated. He replied: "Take no chances, use all three." So in cases of genuine gas bacillus infection give it everything you have.

Dr. Harry J. Warthen (Richmond, Va., closing): The treatment we have followed since we have found our mortality was increasing was débridement—thorough débridement, painstaking débridement. In addition to that we use roentgenotherapy prophylactically. We give the prophylactic dose recommended by Kelly. Each time we give a treatment we take a roentgenogram of the area to see if there is increase in the gas. We feel that diagnosis can be made earlier by roentgenography than by any other method.

Doctor Gage asked about seasonal variation. We looked for that, but in Virginia it seems to develop under any conditions and we could not find anything significant.

IMPROVED METHODS IN EXTREMITY AMPUTATIONS FOR DIABETIC GANGRENE*

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THE SENIOR AUTHOR desires to present two modifications of technic which have been instituted at the City Hospital, New York, to reduce the mortality in midthigh amputations for either arteriosclerotic or diabetic gangrene. These procedures are: First, the sleeve operation for amputations above the knee; and, second, the refrigeration method of anesthesia.

No claim is made to any originality with either procedure, but it has been our privilege to watch and, to some extent, to participate in these procedures, and, therefore, we feel that a thorough evaluation of the operative methods and the end-results may be made.

The City Hospital, New York, receives the poorest risk patients of the metropolitan area. Ambulances of the various city hospitals may take patients either to their own hospitals or to the Metropolitan or City Hospital on Welfare Island. Each of these two hospitals receives on alternate days.

There are two factors, therefore, that militate against good statistics. Frequently an ambulance surgeon picks up an elderly diabetic with gangrene, and, in order not to overcrowd his own hospital, he takes this patient to Welfare Island. The patient is usually a poor risk. Secondly, it is difficult, or impossible, to have an adequate nursing staff at the City Hospital, because nurses object to living on the island. This tends toward inadequate nursing of the sick patient.

We propose to limit this discussion of amputations to those above the knee, as it is this group that presents the highest morbidity and mortality figures. It is necessary, before stating our mortality, to present the conditions noted above, for it is unfair to compare the results of these underfed, elderly patients with the better economic- and age-groups in the voluntary hospitals. In order not to cloud the issue, the figures of the City Hospital series will be the basis of this discussion.

Finley, in 1937, analyzed the series of midthigh amputations at the City Hospital. There were 57 cases with 31 deaths, a mortality of 54.4 per cent. From 1938 to 1941, there were 63 amputations with 39 deaths, a mortality of 62 per cent. During these years there was not a well-organized peripheral-vascular service, and many operators performed many types of amputations, but the guillotine or the modified anterior and posterior flap method was used the most frequently. Three years ago the peripheral-vascular surgical group

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was assigned to Dr. Lyman Crossman, and under his efficient direction progress became immediately apparent.

The senior author has observed the excellent results at the Veterans' Hospital, where Fuller had worked out a modification of the Callender operation, with particular reference toward preserving the collateral superficial blood supply about the knee; and, second, the production of a well-padded stump adapted for an artificial leg.

This operation was introduced at the City Hospital and has been adopted, with a few modifications, by the peripheral-vascular service under Crossman's direction.

Following are the details of the technic as practiced by Fuller: A circular incision is made at the level of the insertion of the patella tendon in the tubercle of the tibia. The skin and fascia are incised in the primary incision, and, as they are incised they are held together by skin clips in order to prevent subcutaneous fat separating from the fascial sheath. This technic is carried out in the entire circumference of the extremity, completely dividing the fascial envelope and skin together. The patella tendon is then transected above its insertion to the tibial tubercle; following this the biceps tendon is cut near its insertion at the head of the fibula, exposing the lateral border of the popliteal space. If no tourniquet is used, the finger is inserted into the floor of the popliteal space through the loose areolar tissues, and the vessels and nerves are lifted from the floor of this space. A tape is passed around the vessels and tied securely. The vessels are clamped distal to the tape and the vessels and nerves cut. The lateral hamstring tendons are then transected. A towel clip is then placed on the divided patella tendon and the anterior aspect of the flap is raised, revealing the ramifications of the quadriceps bursa.

From this point forward, all structures are sleeved-out, using a Mayo dissecting scissors and closely following the margins of the femur. With the index finger of the left hand, to guide the scissors, the fascial attachments along the epicondylar ridge and the femur itself are separated. This coning-out process is carried out until all fascial attachments of the femur are freed to the desired level, preferably the junction of the middle with the lower third of the femur, well above the condyle. The muscle is then protected either by moist towels or with a metal cuff, and a Gigli saw placed about the shaft of the femur. The femur is then transected, the towel or guard removed, and the entire skin and muscle allowed to drop back over the end of the femur. At this stage the vessels which have been grasped earlier by the tape may be individually isolated, ligated and cut. The sciatic nerve is identified, dissected upward, injected with alcohol, and ligated. The patella is excised from the patellar tendon and the wound allowed to drop back together. The clips which join the fascia to the skin are removed, the fascia is loosely sutured, and, if there is no infection and no drainage is contemplated, the wound is loosely closed with interrupted silk. There is no tension.

Where refrigeration is employed it is unnecessary to place a tape about the vessels, as a tourniquet controls the bleeding.

A small series of cases was carried out with this method before the introduction of refrigeration. There were 13 patients operated upon with four deaths, a reduction of the mortality to 33.4 per cent. Still a long way from the ideal!

The problem of anesthesia has been a difficult one, with the aged and infirm type of cases at the City Hospital.

Frederick Allen had worked tirelessly in the experimental laboratory investigating the use of low temperatures as a means of lowering the local metabolic rate to meet the diminished blood supply in the extremities in arterial disease, and, also, he had worked in testing out the anesthetic value of cold. Allen showed that if a tourniquet is applied to a limb of the experimental animal during 54 hours of refrigeration, with a skin temperature of approximately 5° C., the blood does not clot, the vessels do not suffer damage resulting in subsequent thrombosis, and the skin and other tissues remain fresh and intact. Paralysis and other nerve injuries are either prevented or minimized by cold.

The work of Allen was confirmed by Barney Brooks and George Duncan, who showed that rats' tails, rendered completely anemic and refrigerated, could survive more than 96 hours, whereas if the temperature were raised they succumbed much earlier.

Staige Davis showed, a number of years ago, that skin could be preserved in an ice-box for several days and then utilized for skin grafting.

Allen believes that: "Refrigeration of tissues has opened up several new avenues for study. Basically, its action is to reduce metabolism to a point which is just compatible with tissue viability. Thus, in a leg with advanced arteriosclerosis, metabolism can be reduced to a level where the existing circulation is adequate for the needs of the tissues. It is possible in embolic blockage to preserve the tissues by cooling for a sufficient period to allow a collateral circulation to develop, and then gradually to increase the temperature as the tissues can tolerate it. Also if amputation becomes necessary it is undertaken through better nourished tissues.

"In the field of anesthesia, refrigeration introduces a fundamentally new concept." According to Allen: "It produces an anesthesia of protoplasm instead of a nerve anesthesia." This reduction of temperature produces in the tissues a physiologic blocking of nerve conduction. Along with this, shock is apparently nonexistent, and the low temperature causes a marked inhibition of bacterial growth and enzyme action.

"Animal experimentation, as well as observation in human cases, has shown that cold prevents agglutinating processes such as are seen in the formation of fibrin between the surfaces of a sutured wound. In this way drainage can be maintained in an amputation stump wound as long as is necessary and healing will begin only when the temperature has been allowed to return to normal."

With this experimental background, Allen and Ruggiero, under the stimulation of Lyman Crossman, decided to make the first comprehensive study of

refrigeration on human beings. The first operation of this series was performed, July 12, 1941, at the City Hospital. A low thigh amputation was performed for arteriosclerotic gangrene.

The technic, according to Ruggiero, is as follows: "Two turns of a gum-rubber tourniquet (about one-half inch in diameter) is securely placed six or more inches above the level of the skin incision, and above the proposed line of amputation through the bone, completely occluding all the vessels. The area which is to receive the tourniquet is previously refrigerated for about ten minutes with cracked ice. Then two turns are placed one on top of the other and the tourniquet is fixed with a strong clamp of the type of Kelly or plain Kocher. Immediately after the application of the tourniquet the extremity is immersed in a bucket of ice-water and cracked ice, for amputations of the foot and lower leg; for amputations of the thigh, the extremity is packed in finely-cracked ice, with the patient lying in bed. The ice is kept in place with a large rubber sheet. It is of paramount importance that ice or ice-water extend above the tourniquet for about two inches. A low leg operation will require about 25 pounds of ice; a low thigh will require about 50 pounds of ice.

"For amputations of the lower leg or foot, immersion for one and one-half hours is sufficient to produce surgical anesthesia lasting up to one hour. For amputations through the thigh, immersion for two hours is sufficient.

"The patient is brought to the operating room with the extremity in ice. He may receive a small preoperative dose of morphine sulphate, but this is usually unnecessary. His ordinary eating routine need not be interrupted. When the surgical team is ready, the patient is placed on the table and his extremity unpacked from the ice. The tourniquet is not removed. The extremity is prepared in the usual way and the surgeon proceeds with the amputation. After the limb is removed and the large vessels are ligated, the tourniquet is removed, and other smaller bleeders are ligated. We have utilized the fine silk technic, avoiding undue trauma to tissues. It is imperative to use cold instruments, and cold saline solution in the procedure. We prefer the Gigli saw to the bone saw. About half of the cases we have closed without drains. In the face of definite infection the stump was either drained or left wide open.

"Postoperatively, the stump is gradually defrigerated, with the use of ice-bags. This time of defrigeration depends upon the blood supply and the degree of infection present. In the presence of good blood supply the ice bags can be removed in 24 hours. Infection increases the time of post-operative defrigeration.

"*Discussion.*—With the method outlined, it is possible to secure complete surgical anesthesia for about one hour—sufficient to perform any amputation. Primary union of the stump occurs. There is no appreciable change in either the pulse or the blood pressure, or of the respirations of the patient during refrigeration, during the operative procedure, or postoperatively. Immediately after application of the tourniquet the patient may feel slight pain, but

this disappears within ten or 15 minutes after immersion in the ice. The general diabetic status of the patient is not made worse. It is possible to amputate through definitely infected areas. The mortality and morbidity at the City Hospital using this method has been materially reduced."

Under the combined use of the sleeve-operation, plus refrigeration, the mortality was again halved, so that in a series of 13 amputations there were but two deaths, or a mortality of 15.4 per cent. Both deaths were due to emboli.

CONCLUSIONS

The amputation, as devised by Fuller, with the careful protection of the superficial blood supply at the site of amputation, is well worth emphasizing. If the fascia and skin are not united by clips in the dissection backwards the fascia may be stripped from the overlying fat. We are all aware that the fascia receives its blood supply from the areolar tissue on its surface, and, therefore, every effort should be made in the damaged vascular patient to preserve this relationship. By incising through tendons there is very little shock or postoperative hemorrhage, and by following the femur closely inside the muscle bundles there is very little danger of the spread of infection. Following the amputation the tissues drop together and are sutured without any tension. The artificial leg-maker at the Bronx Veterans' Hospital, which has one of the best orthopedic shops in the country, is confident that the best midthigh amputation stump is the one that bears weight on the ischium and not on the end of the stump. This bony stump should be at least eight inches long, as measured from the greater trochanter. As the muscles contract, the incision is drawn posteriorly and a very thick muscle pad is left over the femur.

Refrigeration offers a choice of anesthesia in the aged and difficult-risk patient, which is a great advantage. These cases do not show shock when allowed to return to the ward, and they are usually hungry and are fed soon after operation. Pain is relieved by keeping the ice bags about the stump with a small but sufficient bandage over the incision. One might anticipate that thrombi might occur in the long saphenous or femoral vein above the tourniquet during the period of two hours before operation, when the tourniquet is in place. While two of the deaths, noted in this group, were probably embolic in nature, this is an embolic group, and it is hard to state whether this theoretic concept is any factor, until a much larger series has been studied. We have seen cases where there were lymphatic streaks above the knee, which healed *per primam*, so that the application of cold must have some inhibitory effect upon the growth of bacteria in the tissues.

In amputations below the knee it has been possible, with the aid of refrigeration, to be more conservative than has previously been the case. Amputations below the knee have not been discussed in this article because of the limitation of time, but refrigeration and a similar sleeve-operation, beginning just above the ankle, with a longitudinal extension over the fibula, so that the fibula may be excised higher than the tibia, have given very excellent results.

The senior author sees, in the combination of a sleeve-operation and refrigeration, a real advance in the treatment of amputations in the difficult-risk case. Certainly, in our experience, it has done much to reduce the mortality and morbidity in diabetic gangrene amputations above the knee at the City Hospital.

DISCUSSION.—DR. W. F. RUGGIERO (New York, N. Y.): I wish to thank the Association for the privilege of discussing Doctor Bancroft's paper. As in any new method of treatment, there are likely to be some misconceptions, and in this procedure one misconception is that most people think of it as a freezing method. It is not freezing. The temperature of ice is 0° C. It can only solidify water, and the skin and tissues are not plain water, they are primarily colloids and crystalloids in solution, with a freezing point below 0° C. Secondly, the ice is not in direct contact with the skin. It is a film of water at 0° C. in contact with the skin, and freezing of skin and tissues, therefore, cannot take place. In one case, after four hours of ice application, the temperature of the skin was 2° C.

Because this new method simplifies the surgery and inhibits infection, one is likely to forget the fundamental surgical principles of handling tissues carefully and meticulously. The silk used is No. 00, and we only use No. 1 silk for the main vessels. We do not use drainage except where there is definite gross infection or areas of pus; then we leave it wide open.

The procedure has several other advantages: If the patient is in poor general condition it is possible to halt the infectious and gangrenous processes and bring him to a better general condition before operating. Occasionally there is bilateral gangrene, and this method makes it possible to perform one amputation at a time, while halting the process in the other leg. It makes possible more conservative and lower amputations without jeopardizing the patient's life. The use of this method in traumatic injuries will help to prevent gas gangrene and various other infections that follow such injuries.

DR. MARGARET STANLEY BROWN (New York, N. Y.): I appreciate very much being given the courtesy of the floor in order to discuss Doctor Bancroft's paper. This work has interested me very much from its beginning. I am quite frank to confess that I was "from Missouri" at first, as I could not see how this treatment could do what they claimed. But after seeing it at first hand, and after carrying out the procedure myself, I am equally frank in saying that I am "sold" on it.

What Doctor David said this morning about the need of adapting treatment to suit the type of patient handled, applies very well here. The City Hospital patients come from the poorest possible social stratum. They are in the upper age-bracket. They live under poor hygiene, their nutrition is very deficient, and the majority have diabetes.

What the treatment does is literally to put them on ice and cool them down until they can be gotten into better condition. With ice bags around the leg, the inflammation subsides and their toxicity diminishes. They can be given fluids and a well-balanced, high vitamin diet. Their diabetic status can be studied.

When ready for operation the refrigeration treatment offers an anesthesia free from shock, which is such a hazard to old people. The condition of the patients on their return to the ward is excellent. Many of them eat a large meal immediately after operation, and enjoy it. Their postoperative course is smooth and, while there are sometimes small areas of slough along the

suture line or in the fascia, there are none of the massive sloughs involving the entire stump.

I hope that some of you will have the satisfaction of following some of these cases, and I am sure you will agree that the postoperation expression on their faces tells the story far better than I can.

DR. CHARLES VENABLE (San Antonio, Texas): In 1924, I reported a series of cases on which a periarterial sympathectomy had been done in the early stage. I made the observation that in diabetic gangrene the patients who had this done improved, and gave us a selection of time for amputation and a healing stump that was better than any I have ever seen, and I have continued since then to do periarterial sympathectomy in these cases.

DR. BARNEY BROOKS (Nashville, Tenn.): This report of Doctor Bancroft's, as well as those of other observers, concerning the advantage of refrigeration prior to amputation of the extremities, is of great interest to me. I must confess I have some difficulty in understanding how cooling of a part of a body which has been deprived of its circulation by the application of a tourniquet, and which is subsequently to be amputated, should exert any beneficial effect. I believe it is also important to point out that our experiments have shown that refrigeration has a very effective influence on the preservation of the vitality of tissues deprived of circulation; but that although refrigeration prevents the appearance of the usual manifestations of infection, after refrigeration is discontinued, there is definite evidence that the destructive effects of infection may actually be increased.

DR. FREDERIC W. BANCROFT (New York, N. Y., closing): Refrigeration provides an anesthetic which is accompanied by very little shock. Many of our patients were in the 70 and 80 age-group, and they were the neglected type of case. They show very little shock at operation, and on being returned to the ward are allowed to eat. If ice bags are employed over the dressing for three or four days postoperative, we have not noticed necrosis. There has been some delay in healing, and it is advisable not to remove the sutures before the twelfth day. Some of these patients do have some tissue sloughing, but I have not been able to feel that it has anything to do with refrigeration. It may be wise to suggest that the preoperative therapy is not actual freezing, as the temperatures taken by skin thermometers show them to be about 5–10° C. Where there is chopped ice there are air spaces which prevent the temperature from getting too low.

INTERINNOMINO-ABDOMINAL (HINDQUARTER) AMPUTATION*

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SINCE Gordon-Taylor and Wiles's[5] complete study on interinnomino-abdominal amputation, new interest has been aroused in this therapeutic procedure. Most surgeons have encountered pathologic conditions involving the innominate bones or upper portions of the thigh and adjacent pelvis for which therapy has been inadequate. No surgeon, except Gordon-Taylor, has had any experience of consequence in the undertaking of this formidable type of surgery. Nevertheless, there are times when such heroic measures offer the only possibility, at present, for the relief or for the eradication of an otherwise impossible situation.

In a subsequent report five years later, Gordon-Taylor[6] stated that he had performed the operation six times during the intervening period, bringing his experience to 11 cases. He mentioned that W. H. Ogilvie, Harry Platt, Duncan Fitzwilliams and Grey Turner, among English surgeons, also had employed this operation successfully—some of them more than once; and that Harris, of Toronto, and McCaw, of Aukland, had done it as well. I could not find reports in the literature by these surgeons except in the case of Fitzwilliams.[3] Consequently, as Gordon-Taylor himself gave no references in regard to these operations, I assume that this statement was made from personal communications by them to him.

The literature from 1935 to date reveals that in addition to the six new cases of Gordon-Taylor[6] there have been possibly 12 others reported.

Brief accounts of these cases are as follows:

Banet and Nobo:[1] Male, age 27. Fibrosarcoma of lower end of left femur. One transfusion. Anesthesia not stated. Operation—shock. Transfusion. Radiation therapy 1,000 r. units. Outcome not stated.

Fitzgerald:[2] Male, age 13. Osteogenic sarcoma of right hip. Spinal anesthesia. One transfusion. Out of the hospital walking on crutches in 22 days. No late report.

Fitzwilliams:[3] Male, age 62. Rhabdomyosarcoma of vastus internus, with extension to gluteal region. Three transfusions. Good recovery. Up and about, oldest recorded patient to undergo this operation. No late report.

Gersh:[4] Male, age 60. Sarcoma upper epiphysis and neck of femur. Spinal anesthesia. Good recovery. Wound infected; extensive erysipelas. Two months, severe hemorrhage from wound. After one month, death from cachexia. Postmortem: Recurrence deep in wound; sacro-iliac joint; symphysis pubis; peritoneum. Hemorrhage from newly formed vessels in tumor.

Leriche and Stulz:[7] Male, age 33. Chondromyxoma of left thigh with extension to pelvis. Ether, plus procaine to nerves. Good recovery. Some of flap sloughed, grafted, up on crutches in two and one-half months; not quite healed.

Leriche and Stulz:[8] Male, age 29. Ewing's sarcoma, diffuse, left femur, with spontaneous fracture. Ether, plus procaine infiltration. Good recovery. Healed and walking with crutches in three weeks.

Padovani:[9] Male, age 18. Enormous tumor right pelvis—myeloma. Ether, plus procaine to

* Read before the Southern Surgical Association, Pinehurst, N. C., December 9–11, 1941.

nerves. Two transfusions. Normal healing. General condition not improving since operation; anemia, etc.

Pascalis:[10] Male, age 44. Osteosarcoma left iliac region. Spinal anesthesia and ether. Transfusion. Patient died.

Rapant:[11] Male, age 29. Recurrent osteogenic sarcoma upper third of left femur. Two transfusions then spinal percaine anesthesia. Patient gained weight postoperatively but metastasis occurred in right iliac bone.

Rapant:[11] Male, age 14. Osteogenic sarcoma of the left femur. Ether anesthesia. Collapse. Intravenous therapy. Transfusion next day. Two weeks later was healed.

Ricard and Clavel:[12] Male, age 36. Malignant tumor of upper end of femur. Bad shape. Repeated transfusions before operation. General anesthesia. Transfusion. Good day following operation but died in following night, suddenly.

Shvarts:[13] Male, age 48. Periosteal sarcoma of the left hip. Ether anesthesia. Transfusion during operation. Drainage. Patient died 27 days postoperative from reactivation of an old tuberculous pulmonary lesion and septicemia. The latter was due to necrosis at the seat of operation.

FIG. 1.—Case 1: Destructive lesion about hip joint with soft tissue mass laterally and medially.

I should like to record four causes in which interinnomino-abdominal amputation was performed at the Strong Memorial and Rochester Municipal Hospitals.

CASE REPORTS

Case 1.—Hosp. No. 43193: I. D., female, age 51, was admitted to the Strong Memorial Hospital, November 2, 1939. For two years or more she had had mild pain in the right hip. This caused her to limp. Gradually the pain became more intense, radiating up and down the leg especially to the region of the knee joint. Several physicians treated her without benefit. The limp by this time was pronounced. The pain had also

increased to such an extent that she was sent to the County Hospital in February, 1939. Because roentgenograms were suggestive of tuberculosis, she was transferred to Iola, where she remained for five months. A plaster spica relieved her of pain, but after four months in it the disease showed no evidence of improvement. A needle biopsy confirmed the diagnosis of a malignant tumor. She had stabbing pains in her right thigh whenever the right hip was moved. Otherwise she remained free of discomfort.

Examination showed a rugged woman, with pallor. There was a mass palpable in the right lower quadrant. The right hip was moved guardedly. There was very little joint motion present. There was apparent shortening of one inch. The limb was held in complete extension, with about 15° of external rotation. There was evidence of muscular atrophy of the whole limb. A firm, palpable, tender mass could be made out between the iliac crest and the great trochanter. This swelling seemed to connect with the mass in the right lower quadrant. The right inguinal nodes were firm, enlarged and quite tender.

Her vital signs were normal. Laboratory examinations showed normal red and white blood cells and hemoglobin. The urine had a trace of albumin but no sugar. Roentgenograms gave evidence of an extensive destructive lesion about the acetabular region, incomplete outline of the femoral head, and a large soft tissue mass laterally, above the femur, and medially encroaching upon the pelvic cavity (Fig. 1).

She was given a thorough course of roentgenotherapy to the hip during the course of the next month. She received 40 treatments of 300 r. units, for a total of 12,000 r. Her pain was lessened somewhat but there was no appreciable effect on the tumor. Surgery was advised at this time but she wanted time to think it over. She remained at home for one month, staying in bed and suffering severe pain on any motion of the hip. The tumor had made some growth progress during this time but there were still no signs of lung metastases.

On January 9, 1940 a right interinnomino-abdominal (hindquarter) amputation was performed. She had acute retention requiring catheterization for two days postoperatively. There was moderate distention which was relieved by a Wangensteen suction tube. She ran a moderate febrile course during the next ten days. On the eleventh day she drained foul pus into the vault of the vagina. There had been an abscess in the prevesical space from which *E. coli* and anaerobic streptococci were cultured. This cavity was drained adequately by making an incision above and introducing through-and-through drains. The temperature returned to normal following this treatment. The infection was gradually brought under control and the sinus closed in. Her bowels were kept constipated by opium pills till the sixth day postoperatively. After that time there were almost daily controlled movements, without difficulty. She began to walk with the aid of crutches after the fiftieth day. She was discharged from the hospital in excellent spirits, without any complaints, two months after entry.

Pathologic Examination.—Gross: The specimen showed a tumor mass measuring 18x12x10 cm. It was boggy and gelatinous in consistency. It surrounded the upper ramus of the pubic bone, arising from a broad base over the obturator foramen. The bone was fractured in this area. The tumor was egg-shaped, well encapsulated, and had an anterior globular extension, about 8 cm. in diameter, over the hip joint. Gelatinous tumor tissue was found within the joint capsule. The capsule of the tumor had been broken in one small area near the medial side (Fig. 2).

Microscopic examination showed cartilage as the predominating cell type, though there was an abundance of myxomatous tissue as well. Spindle-shaped cells were scattered throughout the tumor. Frequent mitoses were observed. Tumor tissue was seen within the lumen of a blood vessel in one section. *Pathologic Diagnosis:* Osteogenic sarcoma, chondro-type (Fig. 3).

She was readmitted to the hospital, December 10, 1940, because she had lost weight, had increased thirst, and frequency of urination. She began to have pain referred to her

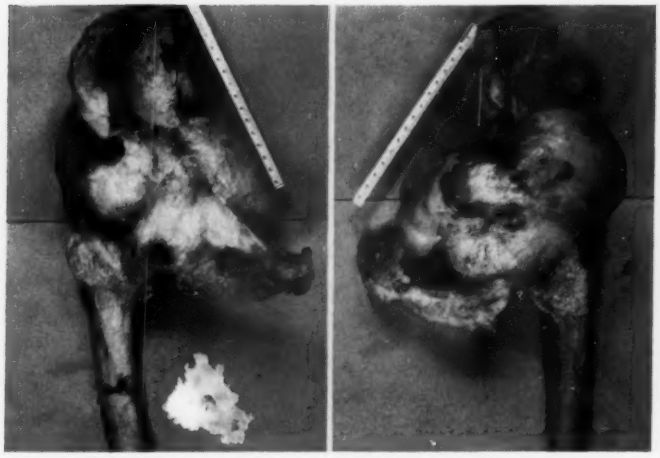


FIG. 2.—Case 1: Gross specimen. Osteogenic sarcoma—chondro-type.

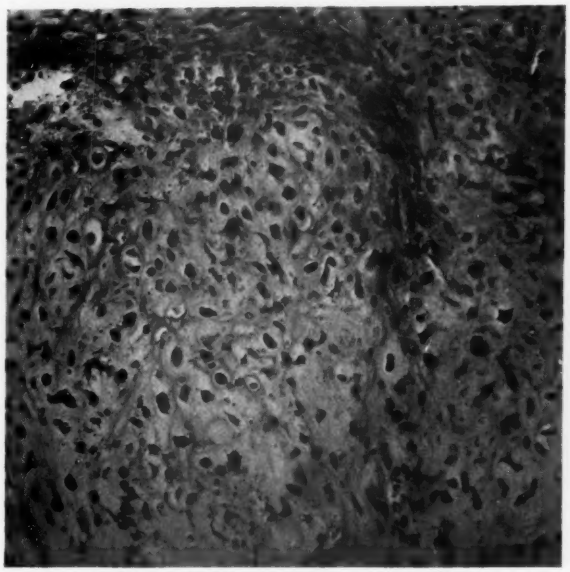


FIG. 3.—Case 1: Microscopic section. Osteogenic sarcoma—chondro-type. (×210)

amputated leg shortly after leaving the hospital. This had increased in severity. There was also a small sinus present on the stump.

Upon examination, she was found to have diabetes. This was brought under control with insulin. The sinus tract was excised under pentothal sodium anesthesia. Two pieces of silk which had been used to ligate the external iliac artery formed the basis for the sinus. Roentgenograms of the lungs showed areas which were suspicious of a pneumonic process. She was discharged in good condition, December 29, 1940.

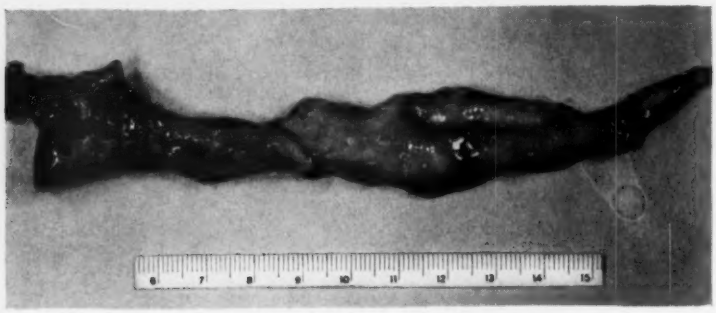
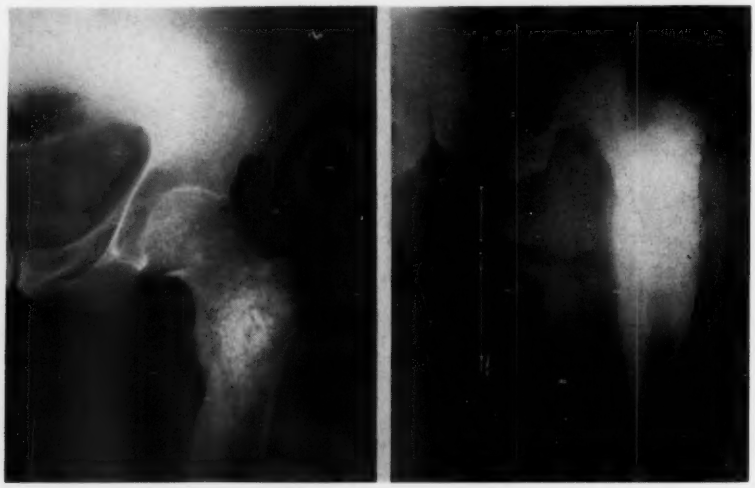


FIG. 4.—Thrombus of tumor tissue found in the right iliac vein at postmortem examination.

She continued to have pain referred to the amputated leg and knee. On January 6, 1941, she felt weak, drowsy, and listless. She had been receiving morphine pills every 3–4 hours for pain. She had a cough with no sputum production. There were many râles at both bases, more on the left than on the right. A diagnosis of metastases to the



FIGS. 5 and 6.—Roentgenograms taken in 1935 and 1940 showing the progressive growth and extension into the soft parts.

lungs was made. The patient was sent to the County Hospital. She was kept comfortable there, with sedation as necessary. She died February 4, 1941.

Autopsy.—The tumor had recurred in the right pelvic region. There was invasion of the sacrum and the muscles of this area. A tumor thrombus occluded the right iliac vein, with extension into the inferior vena cava (Fig. 4). Tumor thrombi were found in both pulmonary arteries. Numerous metastases were present in the lungs, bronchial lymph nodes, liver, spleen and left kidney. There were multiple infarcts in the left kidney, with tumor thrombi in the renal arteries. There was an old organizing pneumonia.

It was of interest that one of her sisters died of "carcinoma of the liver" and a brother has diabetes at the present time.

Case 2.—Hosp. No. 161737: M. M., white, male, age 54, was admitted to the Rochester Municipal Hospital, February 1, 1940. He had had rather severe pain in his left hip for the past eight years. He was admitted to the Genesee Hospital, Rochester, N. Y., four years ago. A tumor was exposed and curetted away from the region of the greater trochanter. It was thought to be a slow-growing osteochondroma from the microscopic examination. Some doubt must have remained in the mind of the clinician for hip joint amputation was advised and refused. Following this, a course of roentgenotherapy was administered at the State Institute for Malignant Disease. There was a gradual recurrence of the tumor, with diffuse enlargement of the left hip region. Stiffness of the joint and pain on weight-bearing became annoying features. The pain was almost constant, kept him awake at night, and required opiates for relief. He received an injection of 1 cc. of 95 per cent alcohol into the second lumbar spinal canal at the State Institute for Malignant Disease, August 15, 1939. Some relief was obtained, but it was transient. Other sequelae of this treatment were weakness of the left leg, numbness and tingling of the left foot, and a constant sensation of coldness in the left leg. He also had difficulty in starting bowel movements and urination. At the date of entry, there was considerable iliosacral pain on sitting, lying, or standing. He had to get out of bed three to four times a night to get relief.

Examination showed an obese man, with the left hip held in 45° fixed flexion. There was a firm, bony-hard, globoid mass involving the whole upper end of the left thigh. It was an enormous tumor with ill-defined margins. It infiltrated the gluteal muscles posteriorly. Apparently, the pelvis was invaded by it. The upper half of the thigh was tense and tender. There was a long curvilinear scar over the lateral surface of the growth. A sinus, with swollen, reddened edges, discharged thin, serous material. Any attempted motion of the hip was accompanied by pain. The muscles of this limb had poor tone and there was very little muscular power left. Marked atrophy was apparent in the leg muscles. Examination otherwise was essentially normal.

Laboratory studies showed a mild secondary anemia. The blood total proteins were normal. The Wassermann reaction was negative. Culture from the sinus grew *B. subtilis*. Roentgenograms revealed a soft tissue mass over the trochanteric region completely surrounding the bone. The cortical line of the bone had been destroyed from the hip articulation down to the midshaft. Irregular cotton-wool density was present externally to the shaft. Bone destruction and irregular bone production were evidences of an osteogenic sarcoma, chondro-type (Figs. 5 and 6). Roentgenograms of the chest showed no evidence of metastasis.

A modified hindquarter amputation was performed, February 7, 1940. The modification was necessitated by the fact that the gluteal muscles had to be sacrificed because they were infiltrated by tumor. Accordingly, an attempt was made to preserve the skin over the adductor muscles together with the obturator artery as blood supply so that this block of tissue could be rotated upward to cover the stump. The adductor muscles did not appear well vascularized at the close of the operation so they were removed. The operation was well borne. The skin looked pallid but there was no tension on it. Although its survival was questionable, it was left in place for the time being. The upper part appeared necrotic and was removed five days later. Most of the rest of the skin also came away during the next week. Dakin's solution was applied to the wound, alternating with normal saline. Clean granulations resulted. Split, thick grafts and pinch grafts were used to cover in the granulating area. Epithelization gradually took place. He began to walk with crutches, progressing quite nicely before his discharge from the hospital, 60 days after admission.

He was put on constant bladder drainage immediately after operation. This was discontinued after one week. Bladder function appeared to be normal while in the hos-

pital. But three weeks after discharge he had difficulty in voiding, frequency, urgency, and terminal dysuria. Urine culture showed *E. coli*, and *Staphylococcus albus hemolyticus*. There was no residual urine. There was an anterior stricture found which was dilated up to a No. 24 F. sound. This gave him complete relief from his urinary complaints.

No attempt was made to regulate the bowels. He did not have a movement until one week after operation. After that the function appeared to be regular without necessity of any medication.

Pathologic Examination.—Gross: The specimen consisted of a huge, rather diffuse tumor, involving the upper end of the femur, particularly the lateral aspect. There was a dirty, 1.5 cm., ulcerated area in the region of the greater trochanter. This was the

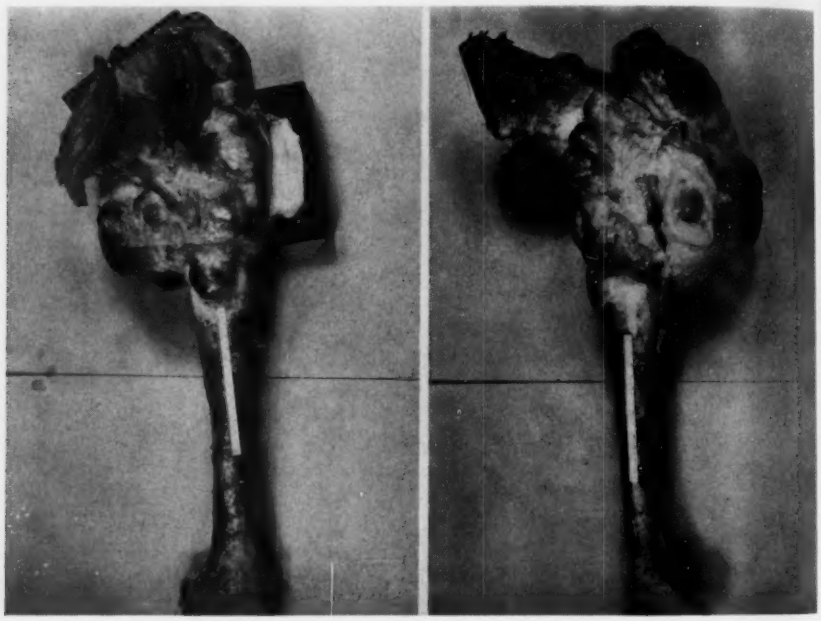


FIG. 7.—Case 2: Gross specimen. Osteogenic sarcoma—chondro-type.

sinus from the previous operation. The tumor was exposed after dissecting away the psoas and gluteal muscles. It was encapsulated, boggy, dull gray in color, and measured about 25 cm. in diameter. The tumor was lobulated, and upon section into the capsule grayish-pink, jelly-like material was released. The tumor tissue had extended laterally into the old operative area. The hip joint was buried in the mass which involved the entire upper fourth of the femur, and was in contact with the pelvic bones above. There were three smaller tumor masses, up to 3 cm. in diameter, along the posterior surface of the femur below the main tumor (Fig. 7).

Microscopic sections showed an intact connective tissue capsule. Some portions of the tumor were entirely myxomatous in appearance. Usually, in this myxomatous stroma there were several types of cartilage cells. The most common type had a pale pink nucleus surrounded by a clear halo and then a dark membrane. Similar nuclei were larger and vacuolated. Scattered smaller cells with dark staining nuclei were present. Occasional mitotic figures were encountered. Very pale young cartilage was observed in some areas (Fig. 8).

He was practically asymptomatic until a recurrent tumor was noted in the stump. This was accompanied by some local pain. There had been some sensation of pain

referred to the absent limb at times. He had gained weight. He got around on crutches quite well. The recurrent tumor measured 8x10 cm. of indurated tissue, intermingled with the old skin grafts. The whole skin-grafted area was excised, and with it a mushy, gelatinous tumor, about the size of a grapefruit, which extended down to the bone. It ruptured in several places during removal, but the area was thoroughly washed with saline solution and left open to granulate. Pathologically it showed chondrosarcoma with myxomatous change (Fig. 9). A split thickness graft was sutured over the granu-

FIG. 8.

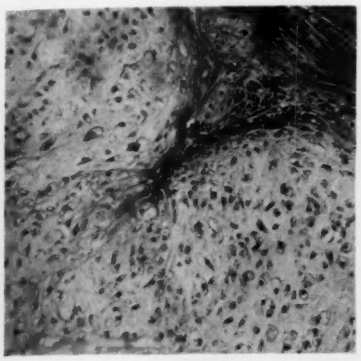
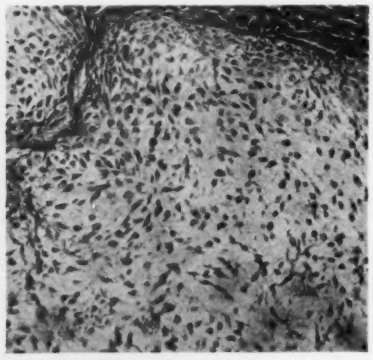


FIG. 9.



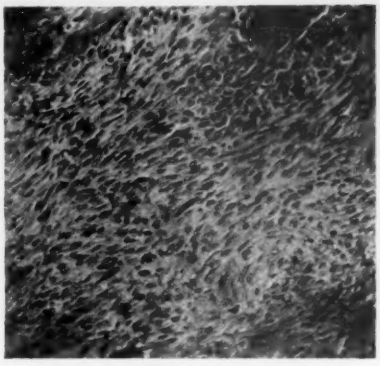


FIG. 10.

FIG. 8.—Case 2: Microscopic section from original resected tumor (×210).
FIG. 9.—Case 2: Microscopic section from recurrent tumor in stump, more aggressive and myxomatous.
FIG. 10.—Case 2: Microscopic section from metastatic tumor in rib. Typical osteogenic sarcoma, with no cartilaginous elements.

lating surface and it healed nicely. The first of these operations was on August 25, 1940, and the second on October 5, 1940.

His next admission to the hospital was December 4, 1940. For about three weeks there has been steady aching along the lower left costal margin and in the back. A lump was found on examination over the tenth rib in the midaxillary line. It was excised *en bloc*, with portions of the adjacent ribs, nitrous oxide-oxygen-ether anesthesia being used. He was discharged December 22, 1940.

The microscopic examination showed this tumor to be absolutely unlike the previous cartilaginous types. It had the characteristics of an osteogenic sarcoma (Fig. 10).

Subsequent Course.—January 14, 1941: He still complained of chest pain and also pain referred to the absent leg. In other respects he appeared to be getting along fairly well.

He developed progressive swelling of the left eye, with dull pain, after leaving the

FIG. 11.—Case 3: Area of destruction in acetabular region.

FIG. 12.—Case 3: Central dislocation of head of femur through tumor of acetabular region.

hospital. There was diplopia on looking to the left. In the Spring, examination showed left exophthalmos, limited ocular motility and increased intra-ocular tension. There was also pain in the back and over the left eye. Relief was obtained by drugs. Roentgenotherapy was administered over the painful areas, with a satisfactory result. It was apparent that the metastases were wide-spread by this time. He died October 3, 1941. Postmortem examination was not secured.

Case 3.—Hosp. No. 162734: A. S., white, female, age 42, was admitted to the Strong Memorial Hospital February 29, 1940. She had complained of pain in the right hip for about one year. Two months before this time she had had a fall. The pain was most severe on weight-bearing. She walked with a limp in consequence. Any rotation of the hip joint caused discomfort.

She appeared to be in acute distress. She was obese and cooperative. Her thyroid gland was two to three times the normal in size and had the smooth, nodular areas characteristic of benign adenomata. There was a soft systolic murmur over the mitral area. There was tenderness on deep palpation over the right hip. Hip flexion was restricted 20° as compared to the other side; also external rotation and abduction were not within 40° of the normal motion of the left hip. She had no evidence of an infectious process. Careful survey for a primary malignant growth revealed nothing definite.

Laboratory studies were all within normal limits. Roentgenograms showed degenerative changes in the lumbar spine. Stereoscopic roentgenograms of the right hip indicated a large, destructive lesion of the right iliac and ischial bones (Fig. 11). Chest films were negative for metastases.

Sufficient biopsy material was not obtained by aspiration of a deeply-seated, pulsating tumor, which could not be adequately exposed. She was given a course of roentgenotherapy, consisting of 3,800 r. units to the right hip, from April 11, to May 2, 1940. On April 18, a small nodule was removed from the neck on a suspicion of malignancy. It proved to be a sebaceous cyst. She was discharged, May 2, 1940, without much sign of improvement. Her diagnosis was uncertain, but a presumption that it might be a primary giant cell tumor of the right ilium and ischium was entertained.

She was given an additional 1,000 r. units of roentgenotherapy during the following week, completing a cycle of 4,800 r. units to the right hip.

On May 26, she fell, striking on her left hip. There was immediate pain in the right hip. She was unable to walk. Pain was severe. Motion of the hip increased the pain. Aching continued in the right hip region without abatement. She was readmitted to the Strong Memorial Hospital June 8, 1940. She appeared to be haggard with pain and long-suffering. Both legs were propped up on pillows, the knees and hips in partial flexion. There was apparent shortening of one inch of the right leg, which was held in 20° of internal rotation and adduction. The right hip was fixed and painful. Roentgenograms showed a pathologic fracture through the right acetabulum, with central dislocation of the head of the femur (Fig. 12). Films of the chest gave evidence of a mass in the anterior mediastinum, displacing the trachea—either a substernal thyroid or perhaps a metastasis. There did not seem to be any alternative to a hindquarter amputation. This was, accordingly, carried out, June 11, 1940. The operation was difficult, and some shock resulted. Transfusion restored her pressure to normal at the close of the procedure. The gluteal muscles were preserved to cover the denuded area which was closed without tension.

The postoperative period was relatively uncomplicated. She voided spontaneously; and the bowels moved without medication on the third day. The wound healed without incident. She was out of bed in two weeks. Within one month she had learned to use crutches satisfactorily. She had pain referred to the amputated limb for about ten days.

The specimen showed a pathologic fracture across the acetabulum, with the femur head projecting through a soft, yellowish-gray tissue (Fig. 13). Microscopic sections were typical of metastatic carcinoma from the thyroid (Fig. 14).

The thyroid gland was subjected to reexamination by a number of surgeons, and

none of them would have made a diagnosis of malignancy from its consistency. She was given a course of roentgenotherapy over the gland—3,900 r. units in about a month. She has been followed in Tumor Clinic since operation. On December 26, 1940, her general condition was good. There was an occasional slight discomfort in the operative

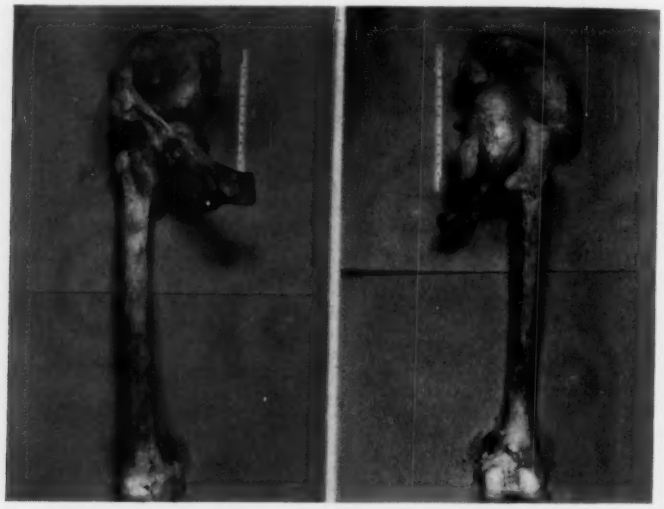


FIG. 13.—Case 3: Gross specimen. Metastatic thyroid tumor, with fracture of acetabulum and central dislocation of head of femur.

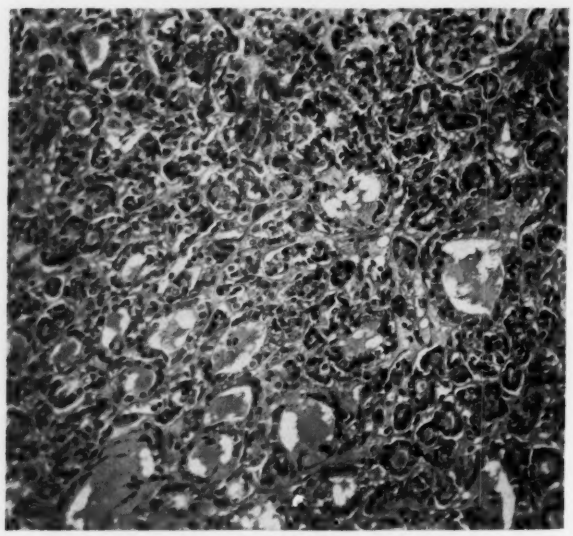


FIG. 14.—Case 3: Microscopic section. Metastatic thyroid carcinoma. (×210.)

area. No definite evidence of recurrence or additional metastases were noted. The thyroid showed little change.

November 6, 1941: The patient showed a gain of ten pounds over her original weight on her first admission. There were no evidences of recurrence nor metastasis elsewhere. The thyroid remained unchanged. She has had amenorrhea for four months, probably

on a menopause basis. The pelvic examination revealed nothing significant. Occasionally she has twinges of pain in her absent limb (Fig. 15).

Case 4.—Hosp. No. 166848: C. J., male, age 55, was admitted to the Strong Memorial Hospital June 26, 1940. He was an intelligent man who had had an interesting career in spite of chronic invalidism which dated from his eighth year. A fall had caused a fracture of the left arm, with bruising of the left hip, in 1892. During the following year there were sharp pains, involuntary contraction of the hip and knee muscles, and failure of the left limb to grow as rapidly as the right. In 1894, a large abscess had formed about the left hip joint. It was opened and pieces of necrotic bone were excised from the head of the femur and the acetabulum. He was in bed for seven months, on pulley weight-traction, in Burlington, Vt. In 1895, an extension steel brace

FIG. 15.—Case 3: End-result.

was worn, but, in spite of this, another abscess formed and was drained. Some iodoform compound was used to irrigate and pack the wound. From 1896 to 1905 there were repeated closures and incisions for abscesses and curettage of dead bone. In 1906 the bone was curetted twice. While a student at Harvard, from 1907 to 1909, there were similar episodes. He spent most of the summer of 1909 in a complete body encasement at Cambridge, Mass. Dead bone was removed on several occasions in New York City between 1910–1914. Roentgenotherapy was tried experimentally, in the latter part of 1914, to see if the condition could be improved. He was curetted for necrotic bone on an average of once a year from 1915–1920. Carrell-Dakin treatment was employed during this period. A heavy compound of wax and bismuth was forced into a dead space in the left groin to promote healing, about 1920. Frequent abscesses formed and dead bone was removed during the next seven years. In 1928, a large piece of necrotic bone was excised from the head of the femur. By 1932, the femur head had completely disappeared, and the socket had been cut or sloughed away. An attempt to induce an ankylosis of the hip area was made in Syracuse, New York. He was in a body encasement for several months. He wore a light celluloid encasement during the rest of the year. The fusion failed, however. The following four years were associated with abscess formation and beginning intense pain. Surgeons tried to remove as much scar tissue as possible, because it was thought to be causing the nerve pain by pressure. Strenuous Swedish massage was employed also to loosen up the scar tissue. As a result of this latter treatment another series of abscesses developed. These were opened during

1936–1938. Treatment with the Kromeyer ultraviolet light, water-cooled tube, was employed, but apparently without effect. In 1938, another attempt at fusion of femur to pelvis was carried out unsuccessfully. Bacteriophage was introduced through the summer of 1939, also "permase," "allantoin," and "urea." The pain continued to be intense. Some days it was difficult to walk on crutches at all. He obtained little sleep. Often, he was more tired on arising in the morning than he was when he went to bed the night before. He had discomfort at times in the area where the bismuth-wax was injected. Pain also centered about the closed sinuses on the buttocks near the back. There were shooting pains on the inner side of the thigh between the groin and knee. He summarized his operations as follows: Between 1892 and 1940 there had been 39 major operations and curettings. He estimated that, in addition, there had been about 20

FIG. 16.—Case 4: Roentgenogram indicating chronic osteomyelitis of left ilium, loss of femur head, and bismuth paste previously injected.

minor incisions with drainage. By May, 1940, he had reached a point where the continuous pain had become unbearable. His attending physicians had made conscientious trials to give him relief by every possible means short of morphine, but finally had to resort to this drug. In consequence, he had been taking ½ to ¾ gr. of morphine daily, for his torturing pain. In June, 1940, he wrote: "Frankly, this is with me a life and death emergency. I cannot work and earn until this pain is conquered."

Examination showed him to be a small, poorly-developed and poorly-nourished man. There were numerous coarse râles throughout both upper lung fields, which persisted following coughing. There was a large, left indirect inguinal hernia. The left leg exhibited a retarded development, marked atrophy, and decrease of active motion. The left hip joint showed abnormal mobility, but with limitation in flexion. The left limb was greatly shortened and deformed. It was useless as far as weight-bearing was concerned. There was an acute infection present. Thick pus was draining from a sinus, posterior to the left hip joint region. A considerable amount of pus could be obtained by pressure over this region, indicating a pocket of some dimensions. Culture showed *Staphylococcus aureus hemolyticus* present. The temperature ranged to 100° F. daily. The white blood count remained at 12,000 during the first week.

Roentgenograms revealed marked atrophy and lack of development of the left innominate bone. The bone had many spotted areas of decreased density scattered

throughout. The head and neck of the left femur were missing, the thinned-out, frail-looking shaft resting against the remnants of the outer shelf of the acetabulum. Two foci of increased density were noted, one centrally, over the ilium proper, and a second in contact with the acetabulum. These areas indicated the injection sites of the bismuth formerly used in treatment (Fig. 16).

It was decided to remove the involved innominate bone. After treating him for ten days, in the hope that the infection would clear up, it was apparent that nothing was being accomplished. The sinus continued to drain freely and the temperature stayed about the same. Accordingly, July 6, 1940, a hindquarter amputation was carried out. Care was taken to avoid the draining area as much as possible but, during the procedure, pus was encountered in several different areas. The external iliac artery was distorted

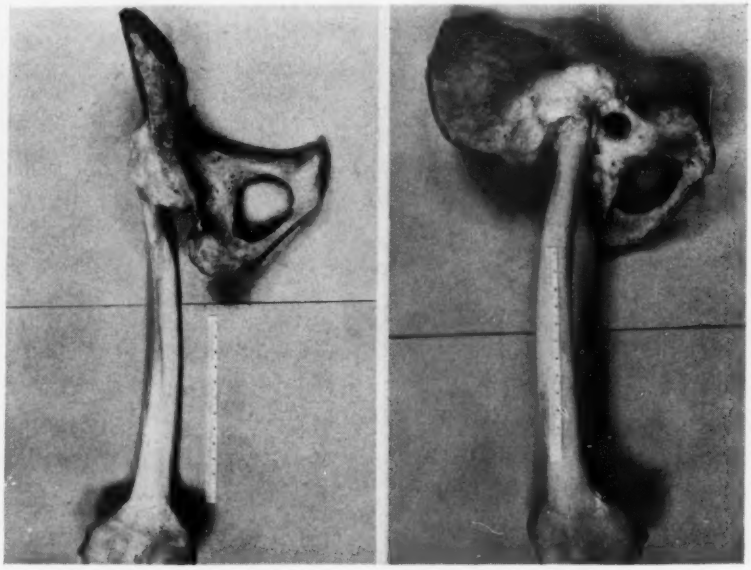


FIG. 17.—Case 4: Gross specimen. Chronic osteomyelitis, left innominate bone.

by adhesions from the injection with bismuth paste. The difficulty was overcome by careful dissection. The sciatic nerve was tied with catgut ligatures, and 95 per cent alcohol was injected between the ligatures. Closure was not attempted except to cover the sciatic area. A small portion of the ilium overlapping the sacrum was left in place. The wound was packed with vaselined gauze after carefully irrigating it with normal saline solution.

Shock was combated by transfusion at the close of operation. He was placed on tidal drainage immediately after return from the operating room. He did surprisingly well. He was sitting, well propped up in bed, reading on the day following operation. He was taken off tidal drainage two days after operation. There was no further trouble with his bladder. His bowels moved spontaneously on the fifth postoperative day. The function became normal, daily, by the tenth day after operation.

The wound was infected after operation but it was in condition to skin-graft it after 19 days. The lower limb of the amputated specimen had been saved by disarticulating it at the knee joint and keeping it in an ice-box at approximately 34° F. Split-thickness grafts were taken from this source and sutured over the granulating area with horsehair. Pressure dressing with a sea sponge was applied. One area failed to take but the rest of the grafts took well and spread rapidly.

His major problem was that of morphine addiction. Attempts were made to break this habit by substitution of other hypnotics. This was only partially successful. Intravenous snake venom was used in 1 cc. dosage on several occasions. Insulin treatment was also employed. During the last three weeks of his hospital stay he received only one dose of morphine. He was dissatisfied with his sedative orders, complained of severe pains in the absent limb, and frequently asked for morphine. It was certain that he would resume the habit as soon as he could be supplied with the drug. He was discharged, with two-thirds of his wound well healed about two months after admission, August 28, 1940. He had been up and about on crutches for one month prior to discharge.

By the middle of November, 1940, he had completely healed over. He still complained of pains referred to his missing limb. No medication completely relieved him, according to his letters. He spent many sleepless nights. In January, 1941, he had resumed his morphine because of unbearable pains in the missing foot. The operation had apparently accomplished little except the removal of a chronic recurring, draining osteomyelitic focus (Fig. 17).

He was readmitted to the hospital, February 11, 1941. Since going home he had shown general improvement. He had been up and about most of the time on crutches. But he had severe pain in the amputated stump. It consisted of a tight constriction in the knee, foot, and toes of the amputated limb. He required ½ gr. of morphine every four hours for relief of this. Examination gave no information of value. Psychologic examination indicated some deterioration from an originally high intelligence level. The psychiatrists felt that he was well adjusted, that he showed no evidence of mental disease; and that the morphine addiction was very mild. On February 28, 1941, a bilateral prefrontal lobotomy was carried out under procaine anesthesia. When the frontothalamic tracts were cut, he declared that the pain in his leg had disappeared. He remained confused and subdued for several days postoperatively. At the time of discharge from the hospital, March 28, 1941, he was caring for himself without assistance. He stated that he still had pain in his absent leg but he did not enlarge on it for 20 minutes as he would previous to operation. He had received no drug of any kind since operation. What the ultimate outcome will be is an open question. A letter from his wife, October 16, 1941, states that he has had no morphine nor other opiate since operation. He has been irritable, abusive and ill-tempered at times. He has returned to work in a minor capacity.

Discussion.—All writers on this subject stress two points: (1) The necessity for careful hemostasis; and (2) the avoidance of surgical shock. There can be no disagreement on these points. Every surgeon should strive for these ideals in every operation. It is only in the means employed to attain these ends that opinions may differ.

Many surgeons are of the opinion that shock can be prevented by blocking nerve channels and thus keeping harmful stimuli from acting. Consequently, spinal anesthesia is advocated; also, careful exposure and local anesthesia to every nerve trunk, especially the larger nerve cords, such as the sciatic. Leriche even advocates interstitial local infiltration of all the tissues. Personally, I do not believe that this makes very much difference.

In none of our cases was spinal anesthesia employed. In no instance were any of the nerves blocked by procaine infiltration. Division of the sciatic by the cold-knife, or by electrocoagulation with the radio-knife was not followed by any appreciable blood pressure change. The blood pressure readings were carefully recorded every ten minutes throughout the operation.

Neither did injection of the severed sciatic nerve stumps with 95 per cent alcohol cause any reaction.

Far more important in causing shock is rough handling of tissues. In our clinic, care and delicacy of manipulation follow the trail blazed by Kocher, Halsted and Cushing, whose contributions in this direction have been too little appreciated.

Consequently, time is of minor importance, especially if the anesthesia is well administered. We feel that less harm results from a deliberate, gentle three-hour operation than by a slashing exhibition of unnecessary speed, with inevitable damage to the tissues. Loss of blood cells and, more important, loss of blood plasma are determining factors in shock. If the circulating blood volume is greatly reduced, the cardiac output, per minute, also will be restricted. The blood pressure will drop, vasoconstriction of the periphery will follow, and surgical shock will result. Measures to save as much of the blood volume as possible should be instituted. Consequently, the external iliac artery should be tied before the vein, and the limb elevated to drain as much of the circulating blood as possible from the part about to be removed. It would be well if this limb could be kept higher than the heart level throughout operation, because there must be approximately one-sixth of the circulatory volume in this large portion of the anatomy. It has been our policy to start a slow intravenous infusion before beginning operation. During the operation as much as 1,000 cc. of 5 per cent glucose, in Ringer's solution, has been administered. If the patient begins to show shock, whole blood transfusions can be carried out through the same apparatus. In our four cases, Case 2 showed no shock; Case 4, relatively little shock, though the blood pressure dropped until transfusion restored it; Case 1 had some shock which required treatment by two transfusions of 600 cc. each. She left the operating room in good condition, with a blood pressure of 100/70 following this treatment. Case 3 had rather severe shock due to two complicating factors—(1) severe trauma of injury; and (2) heavy previous radiation. Consequently, at operation there was considerable blood loss. Two transfusions of 700 cc. restored the blood volume and the patient left the operating room in good condition.

In regard to anesthesia, the surgeons have no general agreement. Many favor spinal anesthesia. This would be a good choice for the more rapid type of operator. But Gordon-Taylor emphasized the necessity of extreme care, especially, when changing the patient's position, as is necessary in this operation. Continuous spinal anesthesia, as now practiced, has not been employed, but might be to advantage. General anesthesia with local block to the nerve trunks has had its advocates. In our cases avertin with nitrous oxide-oxygen-ether sequence was employed in Cases 1 and 4. Sometimes, the avertin depresses the blood pressure at the start. Consequently, only a small quantity would seem advisable, merely as a basal anesthetic. In Case 2, vinethene induction followed by drop ether was satisfactory. In Case 3, simple nitrous oxide-oxygen-ether sequence was employed.

As to the position of the patient on the table, it is best to start with the patient flat on his back. The anterior part of the incision then is made from the symphysis along the iliac crest to the posterior superior spine. The anterior dissection is developed extraperitoneally. The external iliac artery and vein are transfixed by sutures and divided. The division of Poupart's ligament makes for easy access to these vessels. The rectus abdominis is freed and the symphysis divided. The patient is turned on the sound side and the incision carried posteriorly down to the gluteal fold and across the trochanteric region to the inner side of the thigh. The perineal incision joins the inner end of the anterior incision over the symphysis. The iliac bone is divided from the crest to the sacrosciatic notch. Saw, chisel, or bone cutters may be employed for this. The gluteus maximus may be saved in most cases, unless involved by tumor. It is well to preserve its blood supply if possible. The iliopsoas muscle is divided, the pyriformis and levator ani also. The sciatic nerve cords now lie exposed. Division of these huge nerve trunks frees the limb and leaves a gaping wound. The peritoneum and transversalis fascia remain as the sole protection for the peritoneal contents. The small portion of ilium remaining attached to the sacroiliac joint may be removed or left, as indicated. We have found that the orthopedic trough used for hip joint amputation facilitates the handling of the patient and makes the manipulation toward the sound side easily carried out.

While much has been written regarding the type of skin flaps to cover the stump, it would seem that the decision must rest with the type of diseased involvement of the limb. When it is possible to save the gluteus maximus and a sufficient part of its blood supply, it makes a very satisfactory covering. This was possible in Cases 1 and 3. Leriche, in the first of his articles, advocated ligature of the common iliac artery for control of bleeding. But this was followed by necrosis of the gluteal muscle and delayed healing. The majority of surgeons now ligate the external iliac artery only. When tumor tissue has extended into the gluteal muscles, flaps must be developed in other situations. In Case 2, a long flap, supplied by the obturator artery, was raised to cover in the stump. The blood supply proved inadequate and the skin sloughed, necessitating a skin-grafting operation when granulations had appeared. In Case 4, the limb was grossly infected. Thick pus was expressed from the sinuses during operation. A guillotine-type of amputation was, accordingly, performed. No attempt was made to cover the denuded area. In spite of the fact that only the peritoneum and the transversalis fascia remained between the abdominal contents and the outer air, no herniation was observed. After the wound had granulated, skin was grafted. This was taken from the amputated leg, which had been kept in the ice-box at 34° F. for two weeks. Successful grafting occurred in 80 per cent of the grafts applied. Gordon-Taylor saved the epigastric artery whenever possible, so as to preserve the blood supply to the rectus muscle.

Sequelae encountered in these four cases are recorded, so that they may be avoided by future operators. In Case 1, we had a rather severe infection.

I believe that it came through the vault of the vagina which may have been opened at operation. At any rate, the abscess discharged through that area. There had been no preparation of the vagina preoperatively, but in Case 3, we took this precaution. It would seem to be a wise prophylactic measure in female patients.

It was not surprising to have bladder difficulty following operation in these patients. We adopted tidal irrigation as simpler than multiple catheterizations. After two to seven days it was possible to remove the apparatus without further trouble resulting. Case 3 did not require this treatment.

It was thought that detaching the levator ani muscle on one side might upset the evacuating function of the rectum, but this was not the case. At first, we believed that something should be done to constipate the bowels in order to avoid infections. Opium pills were given for this purpose. In the later cases no medication was given. The bowels returned to normal function after three to seven days in our cases, and became regular without medication.

No prosthesis can be fitted easily to this stump. The patients quickly learn to use crutches, and get around well by this means. They learn to adapt themselves to sitting on the involved side. The younger patients, according to reports, adjust themselves more quickly and successfully.

The most annoying of the sequelae was the development of a phantom limb by these patients. They all had it in varying degrees, and proportionate estimation of its nuisance value. This subject is of great interest by itself. We are now making an investigation of it. Attempts to modify this phenomenon by treating the severed sciatic by different methods failed to make any appreciable effect on the outcome.

The fact that we could carry all four of our patients through this severe type of operation without having had any previous experience in it, indicates that it is a feasible procedure for the surgeon when the necessity arises. Fortunately, the necessity for this major mutilation is rare. It has been undertaken for sarcoma of the innominate bones or upper femur, extensive sarcomata of the muscles of the thigh and pelvis, giant cell tumors of the pelvis, and tuberculosis and osteomyelitis of the pelvic bones.

The mortality as given in Gordon-Taylor's first report, of 59.5 per cent, should be reduced. The mortality of 33 per cent, of his later report, can be improved upon. To the precautions advocated by former surgeons, we would add gentleness and lack of urgent speed. The surgeon should keep on moving, however, and not be slow without some object. The availability of blood plasma should be added to the safety factors when such an operation is contemplated.

The results of this operation will be improved when surgeons realize that the operation can be undertaken with relative safety. They will no longer hesitate to offer their patients a chance for cure, which they now deny them. The first two patients of our series were advanced malignancies. They were afforded palliation and comfort. The third patient seems to have a hopeless situation. It may be that this is one of those rare, so-called benign metastasiz-

ing adenomata of the thyroid. Certainly, to date, there is nothing to indicate a further progression of the disease. In Case 4, the draining focus has been eliminated, but the ultimate cure of the mental state must await the test of time. These end-results are not good. But they hold a hope that, in the future, somebody may be benefited by this type of surgery.

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DISCUSSION.—DR. T. C. DAVISON (Atlanta, Ga.): I performed one operation like this 20 years ago or more, and it has never been reported. I did not know then that such operations were so rare. This patient was 70 years of age, and he had been burned severely on the anterior surface of the right thigh and right groin in infancy, which resulted in extensive scarring. Portions of this scar had degenerated and developed an extensive carcinoma with involvement of the lymph nodes. It was very evident that a hip joint amputation was indicated, therefore, a high incision was made above Poupart's ligament and the abdominal peritoneum was pushed upward to the bifurcation of the abdominal aorta. The external iliac artery was ligated and the internal iliac was taped temporarily. The enlarged nodes were removed from the bifurcation of the abdominal aorta downward. The bone was sawed off, including the pubic rami, crest of the ileum, and the acetabulum. A posterior flap from the gluteal region was used to cover the stump. The patient lived for seven years and died of pneumonia.

THE SURGICAL CORRECTION OF MANDIBULAR PROGNATHISM*

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PROGNATHISM is a deformity characterized by an abnormal protrusion of the mandible. The broader part of the lower dental arch lies opposite the narrower portion of the upper arch, causing a malocclusion varying with the degree of the deformity. The protruding chin, with the massive jaw and heavy lips, often results in a very displeasing appearance, which primarily causes the patient to come for surgical aid. It may be due to actual hypertrophy of the bone; errors in the eruption of the teeth; premature extraction of deciduous molars; or to fractures or contracting scars of the face and neck.

Orthodontic treatment should be tried if the patient is under 16 years of age, unless the deformity is very severe or does not involve the dental arches.

There are two general groups of surgical methods for correcting this deformity. One deals with a simple section of the bones on either side, with a posterior displacement of the mandible, held in its new position by fixation of the dental arches.

Various levels of sections are advocated by different surgeons. The cuts can be made in the neck, at various levels of the ramus, or at the angle. A section through the neck is only indicated if the deformity is due to a malunion of a fracture in this area. A section through the angles is of little value since it permits very little backward movement of the body of the mandible. Cuts at various levels of the ramus can be undertaken safely, with care, and have the advantage of avoiding an opening into the mouth and breaking the continuity of the dental arch. The chief objection to these operations is that there may be an interference with function because of the backward displacement necessary.

The second group of operations deals with the removal of sections of bone from the rami or the body of the mandible. Since very few of these cases have an elongation of the rami, any shortening with the posterior displacement necessary for the correction of the deformity will cause interference with function.

The most desirable operations deal with the body of the mandible itself. The corrections resulting from the removal of sections of bone take care of both the protrusion and the widening so often seen. The site of operation depends to a great extent on the denture. If all of the teeth are present, the second premolars can be extracted. Spaces caused by the separation or loss of premolars or molars can be used, providing there are teeth behind to hold the splints necessary. In the appended cases extractions were necessary to secure the space required.

* Read before the Southern Surgical Association, Pinehurst, N. C., December 9–11, 1941.

The main purpose of this communication is to call attention to a simple method of fixation of the three fragments of the mandible after resection and

CASE REPORTS

Case 1.—White, female, age 26. Marked protrusion of the lower jaw with a malocclusion (Fig. 1). The lower first molars were occluding against the upper premolars.

FIG. 1.—Case 1: Mandibular Prognathism. Note protrusion of the mandible, with the heavy lips.

FIG. 2.—Case 1: Roentgenograms of mandible before operation. All of the teeth are present. Note that the incisors tend to turn in, and that there is an open bite. The lower first molars occlude against the upper premolars. There is an hypertrophy of the mandible.

The incisors, both upper and lower, tended to turn in. The body of the mandible was hypertrophied; all of the teeth were present (Fig. 2).

Casts were made of the denture (Fig. 3). The first molars were then extracted and the spaces retained by placing caps between the teeth. The orthodontist placed bands around the second lower molars, with a short tube attached to the buccal surface. Bands

were placed around the premolars on both sides, with a tube soldered to the outer side. The tubes permitted a square threaded-rod to pass through. The cast was now cut in the region of the first molars and the correction made. Careful measurements were taken of the width of the segments removed (Fig. 4).

Bands were placed around the upper first molars and first premolars with a rod soldered to the buccal surface.

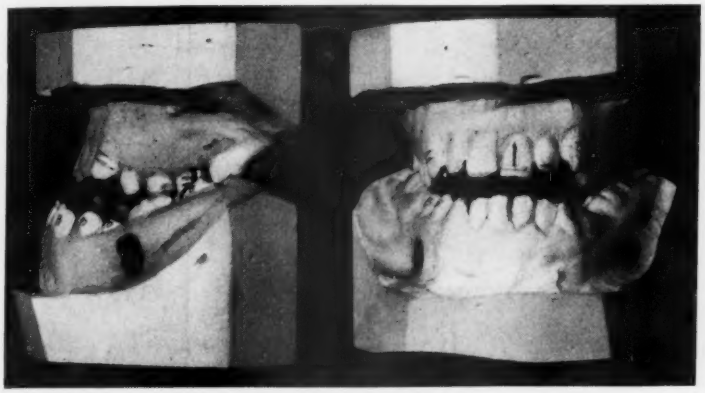

FIG. 3.—Case 1: Casts made of the denture before operation, to determine the location and extent of the operation.

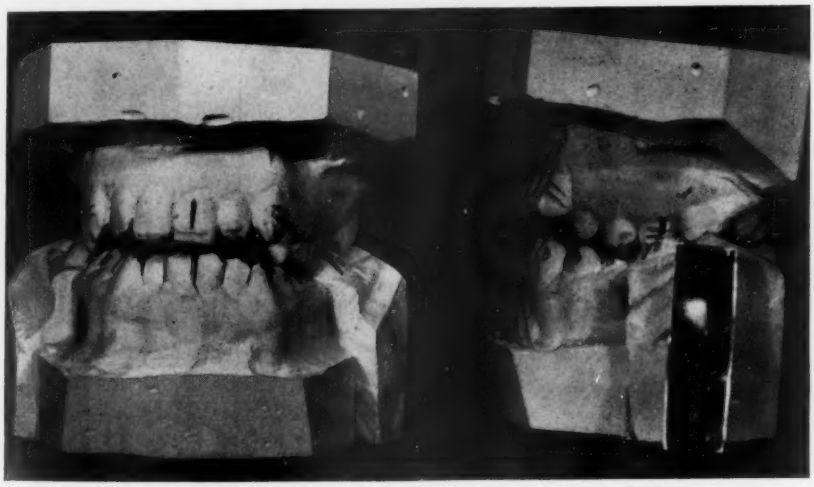

FIG. 4.—Case 1: Occlusion of the casts after the portions were removed. The width of the pieces removed was carefully measured. The remaining malocclusion was later corrected by the orthodontist.

Under general anesthesia, an incision one and one-half inches long was made in the skin under the margin of the mandible, over the area where the tooth had been extracted. The mandible was exposed and the periosteum marked with brilliant green (alcohol 5 per cent solution) according to the predetermined measurements. Two holes were drilled through the bone near the lower margin 0.5 cm. from the marks. A silver wire was threaded through the holes, with the ends to the outside. The periosteum was incised and the section of bone removed with a saw. A similar procedure was carried out on the other side. The four saw-cuts were made almost completely through before the continuity of the bone was broken, in order to control the bone and secure even, accurate cuts. Care was taken to avoid stripping the periosteum back from the margins. The pieces of

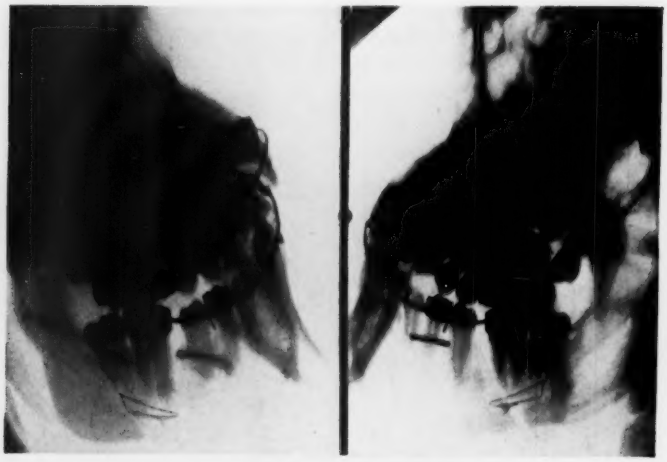

FIG. 5.—Case 1: Two weeks after operation. Note the shadows of the silver wires. The angle at which the pictures were taken makes it appear that the margin of the tooth is in the cut. There was sufficient bone near the roots of the teeth to avoid injury.

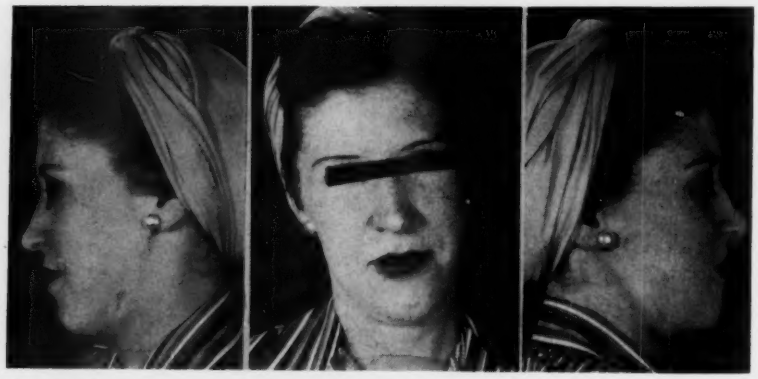

FIG. 6.—Case 1: One year after operation. The teeth occlude. The small scars visible are not objectionable to the patient. The chin has been adjusted to a more normal position.

FIG. 7.—Case 2: Mandibular Prognathism. Patient did not care so much about his malocclusion as about his appearance.

bone were removed and the square rod inserted. Nuts were placed on the threaded ends, which permitted firm approximation. The silver wires at the lower borders were tied firmly. The mucous membrane was approximated inside the mouth. A horsehair drain was inserted from the skin side and the incision closed with horsehair. The ends of the wire were turned to the outside (Fig. 5).

The following day, after the patient had reacted from the anesthesia, the lower jaw was fixed to the upper by wires, connecting the two bars.

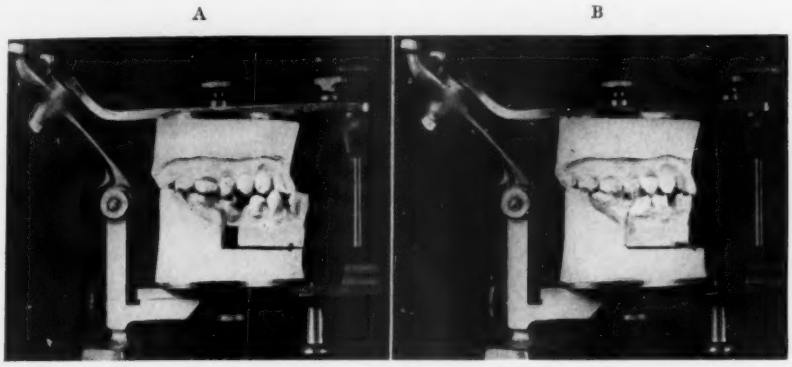

FIG. 8.—Case 2: Casts were made of the denture of both jaws, and placed to show the occlusion. A section was then removed to secure proper occlusion. (A) Segment moved out to show the amount of cast removed, and to show the condition as it existed. (B) Segment pushed back to show the correction. The width of the segments removed was carefully measured.

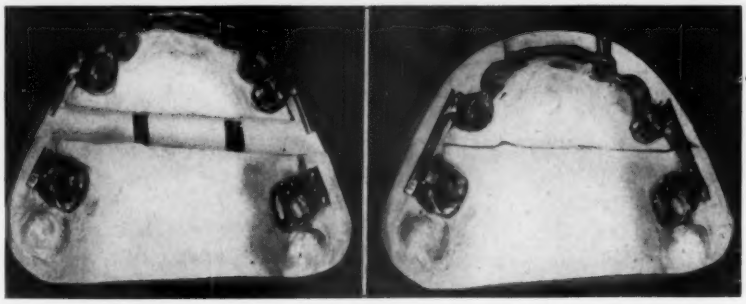

FIG. 9.—Case 2: Golden bridge and caps, with the tubes soldered in place, were made for the teeth on the cast of the lower teeth. (A) The segments pulled apart to show the position of the parts as they would be on the teeth before operation. The two rods, seen in the lower part of the cast, were used to assure correct movement and adjustment of the fragments. (B) Segments approximated and the bolts fastened in position, as they would appear after the operation.

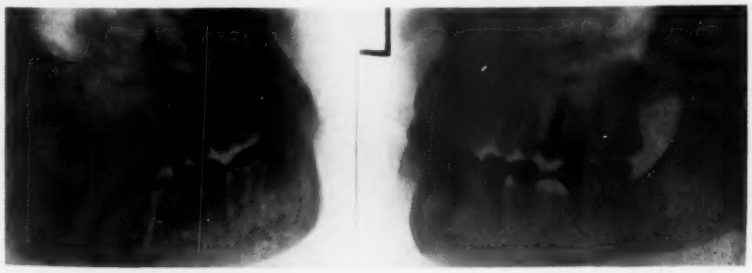

FIG. 10.—Case 2: Roentgenograms of lower jaw, two weeks after operation showing the fragments held in position by the apparatus. The wires in the lower borders are barely visible because the wire was of very fine gauge, being steel.

Recovery was uneventful. The drains were removed in two days, and the sutures in seven days. The teeth were cleaned and inspected every three or four days, when the wires between the bars were changed. The patient was fed a high caloric liquid diet, and only lost three pounds.

After three weeks, the mandible was freed from its immobilization to the upper jaw and the patient given a very soft diet. Seven weeks after operation the apparatus was entirely removed. The silver wires were removed after four weeks, and the openings healed, leaving small adherent scars. There was some motion in the front segment for a few months, which gradually disappeared as the callus became firmer. The lower lip and a part of the chin lost sensation, which returned in a few weeks and became entirely normal in three months. The teeth all appeared viable (Fig. 6).

COMMENT.—The immobilizing apparatus was applied to both jaws, making it difficult to feed and care for the patient. The absolute immobilization made it likely that the callus was slow in forming. The wires turned through the skin caused scars, which were not completely satisfactory although massage finally made them inconspicuous. In view of these objections, a simpler apparatus was planned for the following case:

Case 2.—White, male, age 22. Protrusion of the mandible with malocclusion (Fig. 7). The second premolar was missing on the left side. There was a hypertrophy of the body of the mandible. Casts were made and sections removed to give the desired occlusion. Measurements were taken of the segments (Fig. 8). A golden bridge was made to fit the teeth in front of the second premolars, with a short tube soldered on the buccal surface. A cap, with a tube soldered to it, was made for the first molars. The ends of the short tubes on the molar caps held the nuts firmly set. A short bolt was passed through the tube on each side, which could be screwed into the nut (Fig. 9).

The premolar on the right was extracted, and the operation performed ten days later. We did not hesitate to cut through the newly healed gum, since fractures will heal under similar conditions. The bridge and caps were soldered into place.

Under general anesthesia, incisions, one and one-half inches long, were made through the skin, exposing the mandible at the selected site. The measurements were marked on the bone. Drill-holes were made near the lower margins about 0.5 cm. from the line of the cut, and steel wires passed through, with the ends to the inside of the mouth. The sections were now removed; the bolts passed into the tubes and tightened with a screw-driver. The wires were tied to the inside of the mouth. Horsehair drains were placed in the incisions, which were closed (Fig. 10). The drains were removed in 48 hours. The patient was discharged four days after operation. The skin sutures were removed in seven days, with *per primam* healing. The patient was given a liquid diet for four days, after which a very soft diet was ordered. Chewing was not encouraged, but he could talk as much as he desired. After the second week chewing gum was advised and a diet of soft foods, which required some chewing, was permitted. It was felt that the stress of use would speed the formation of the callus. The loss of sensation began to disappear after the third week, and sensation became normal during the third month. In five weeks, the wires were removed with ease. In eight weeks, the bridge was removed (Fig. 11). The patient had some false motion and a slight tendency to open-bite, which disappeared as the bones became firmer (Fig. 12).

COMMENT.—The advantages of not wiring the jaws together are apparent. The teeth could be easily cared for by the patient himself. The liquid diet was reduced to a short time, so that the patient did not lose weight or become unhappy. He could go about his work after the second week. The wires being turned into the mouth prevented the formation of a sinus and gave

perfect healing. There is no danger in breaking the continuity of the mandible. The nerves regenerate rapidly and the teeth do not lose their vitality. This method permits a careful performance of the operation on the casts, with a definite knowledge that the parts will come together as desired. Infections from openings into the mouth are, apparently, not to be feared. Neither patient was given any of the sulfa drugs.

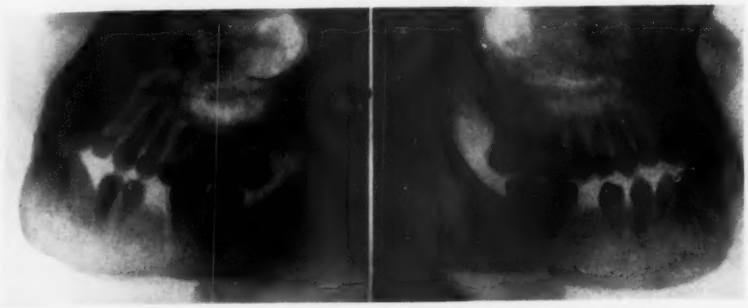

FIG. 11.—Case 2: Roentgenograms of lower jaw eight weeks after operation. The fixing apparatus had been removed together with the wires. The union was firm enough to permit use, even though there was a little false motion.

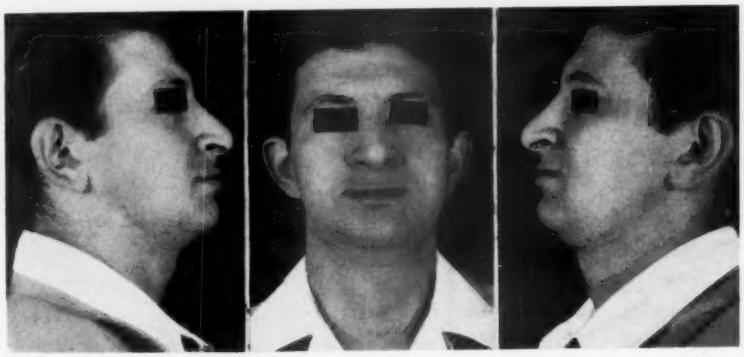

FIG. 12.—Case 2: Ten months after operation. There is still some fulness in the soft parts, which is gradually disappearing. The chin is now in a fairly satisfactory position. Union is firm.

CONCLUSIONS

Operations upon the body of the mandible can be performed without danger of permanent loss of sensation or of the vitality of the teeth.

A simple bridge attached to the teeth will hold the three sections of the mandible together satisfactorily.

Wire suture at the lower margins of the cuts prevent a tendency of the posterior fragments to turn, and will not cause serious damage. Fine steel wire is better than silver wire, since it has more strength in proportion to its diameter.

The author wishes to express his appreciation to Dr. Meyer Eggnatz, who prepared the casts and made the appliances for the first case; and to Dr. G. W. Gaver, who conceived the apparatus, and made the casts for the second case.

SPRAINED ANKLES*

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CINCINNATI, OHIO

"A SPRAIN IS WORSE THAN A FRACTURE" is an expression one has often heard. Scientific minded people are inclined to disregard all such old fashioned phrases as being of no significance. However, the writer has come to regard these expressions as having some merit until proved otherwise. Of course, it is not true that a sprain is worse than a fracture. That would be ridiculous, but there have been many, many instances in which an injury to an ankle or a wrist or shoulder was called a sprain, when some other lesion was present, and as a result, the simple treatment for sprain was found to be inadequate.

The crux of the whole situation lies in diagnosis. If an ankle is truly sprained, the lesion is a very simple one and will promptly respond to simple treatment. The injury consists of stretching of the external lateral ligament of the ankle joint with perhaps a rupture of a few fibers, but without complete rupture of the ligament, and without rupture of the astragalofibular ligament. Such a lesion, if properly strapped, will give little further trouble, should not have a tendency to recur, and, all-in-all, is a minor accident.

However, there are many cases in which the external lateral ligament of the ankle joint is completely ruptured, the astragalofibular and tibiofibular ligaments are also torn, and in which the astragalus becomes dislocated. There may be a very slight fracture at the lower end of the fibula, or the fibula may be intact. The point, however, is that the lesion is primarily a dislocation of the ankle, which has become reduced before being seen by the doctor and before being examined roentgenologically. Such a lesion, if treated by simple strapping, will be stubborn. The patient will not get well promptly, and even when he has returned to work, there will be a tendency for the "sprain" to recur. The patient will consider that he has a weak ankle. Watson-Jones[1] has pointed out that these are the ankles which remain a little thicker and sprain easily.

There are several ways in which the diagnosis of this more serious lesion can be made. The bleeding is always more severe than in the ordinary sprained ankle, and consequently the swelling is greater. The swelling may extend to the opposite side, although there will be no tenderness on the inner side. There is, usually, in these cases, tenderness over the anterior tibiofibular joint, as well as tenderness around the lower end of the fibula, and not just below it. However, there is one certain way of determining which lesion we are dealing with. If a few cubic centimeters of novocain are injected around the lower end of the fibula, that is, below and to the sides of the external malleolus, and then an anterior posterior roentgenogram is made with

* Read before the Southern Surgical Association, Pinehurst, N. C., December 9–11, 1941.

someone holding the foot in as much supination as possible, one can easily tell whether there is a tendency for the astragalus to dislocate or not. If rotation of the astragalus takes place under these conditions, we are dealing with a partial or complete dislocation of the ankle, and not with a sprained ankle. If movement of the astragalus does not occur, then the ankle is merely sprained. We have tried this maneuver without the use of novocain and failed to produce movement of the astragalus, but later, with novocain, did demonstrate the dislocation when the pain had been eliminated.

We, therefore, believe that one cannot be sure unless novocain has been adequately injected, and a real attempt made to supinate the foot before the roentgenogram is taken. These cases, that is, those in which the astragalus can be rotated, cannot be adequately treated with strapping, but must be placed in a plaster encasement, preferably a skin case, with the foot neither supinated nor pronated, and at a right angle to the tibia. A walking iron or heel can be applied early and the patient permitted to walk.

Sir Robert Jones, long ago, pointed out that it was improper to treat a sprained ankle with plaster. This is true if the ankle is merely sprained. His reason was that spasm of the peroneal developed, and the net result was spasmodic pronation of the foot. However, we have not seen this occur in these more serious lesions. Therefore, we would turn to the original statement that the whole crux of the situation lies in the diagnosis, followed by adequate treatment for whatever lesion is present. The same remarks could apply to the employment of novocain. If an ankle is merely sprained, novocain injection is a good treatment, but if a more serious lesion is present, it is entirely inadequate, and great damage will be done if the patient is permitted to get about without proper support.

We have had the opportunity to make some experiments on two fresh cadaver specimens. In one, a roentgenogram was taken with the ankle supinated as far as possible, and no dislocation of the astragalus was observed. Then the calcaneofibular ligament was cut, again the ankle supinated, and this time a very trifling amount of rocking of the astragalus was demonstrable. Following this, both anterior and posterior astragalofibular ligaments were cut and, with a slight amount of supination, the astragalus was rotated markedly. In the second case, we first cut the astragalofibular ligament without cutting the calcaneofibular ligament. Again the astragalus could not be dislocated, but when the calcaneo-astragaloid ligament was cut in addition, severe dislocation occurred.

It appears, therefore, if this small number of experiments are of any value, that it is necessary for both groups of ligaments to be torn before the dislocation can occur.

REFERENCE

[1] Watson-Jones, R.: Fractures and Other Bone and Joint Injuries. 2nd ed. Baltimore, Williams and Wilkins Co., 1941.

DISCUSSION.—DR. CLAY RAY MURRAY (New York, N. Y.): I should

like to take this opportunity to express my appreciation of the privilege of being your guest and of the pleasure this occasion gives me. I feel impelled to comment on one point in Doctor Carothers' paper.

Doctor Carothers has called attention to a very important fact, that the recurrent sprained ankle is not an ordinary sprained ankle, and that the exact diagnosis cannot be made without using special diagnostic measures. But I think he has, more or less, "missed the boat" on the point of the exact nature of recurrent sprained ankle. He has demonstrated that cutting various ligaments has the effect of producing instability in the ankle joint mortise. I very much doubt, on the other hand, that the astragalofibular ligaments are ever torn in these ankle sprains. I know, however, that the ligaments of the inferior tibiofibular joints may be torn without any roentgenographic evidence of diastasis in the joint by the ordinary technic for ankle joint roentgenography, unless novocain is injected or an anesthetic administered, and the attempt is made to spread the tibia and fibula apart by manipulation of the foot. An actual spread, with tilting of the astragalus, can then be made evident. It is my impression that this is the lesion with which we are dealing in the living human being in cases of recurrent ankle sprain, and I believe the tests described should be made in any fresh ankle sprain in which pain and tenderness over the inferior tibiofibular joint can be demonstrated, or in which a hemarthrosis of the ankle joint exists. I must admit that there may be other combinations of ligamentous tear which might produce the same effect, but I assume Doctor Carothers is discussing this type of sprained ankle as it occurs clinically, outside the autopsy room, and this is, I believe, due to the lesion which I have described.

Dr. George E. Bennett (Baltimore, Md.): Doctor Carothers' statements are quite true, and he has emphasized a proven experimental point, namely, that tearing of ligaments is productive of serious disability. I think it would be wise for Doctor Carothers to extend his research a bit further. My impression is that some of the very serious so-called sprained ankles are due to a tearing of the tibiofibular ligament and a spreading of the joint mortise. I would like to suggest to him that after the division of the ligament, a roentgenogram be made with the foot in full plantar flexion and in full dorsiflexion, to ascertain the mobility of the fibula after the ligaments have become detached. On a number of occasions I have operated upon joints of this type, reconstructing the tibiofibular ligament to relieve this painful relaxation.

Dr. Isidore Cohn (New Orleans, La.): It is unfortunate, I think, that we often forget classic work done in the past. Ross and Stewart, in Philadelphia (1911), undertook to study the question of sprains and sprain-fractures, experimentally. As a result of their experiments they concluded: "The integrity of joints is maintained by strong ligaments, and in order to have a luxation one or more of the strong ligaments must give way; we have shown that ligaments themselves do not give way, but the bony tissues to which they are attached give way, therefore, we think that probably all luxations are permitted by the primary occurrence of a sprain-fracture." This experimental work was corroborated by their clinical experience.

My own clinical experience has led me to feel that, in most instances, a sprain-fracture occurs rather than a laceration of ligaments about joints. I believe that the bony prominences to which the ligaments are attached have less tensile strength than the ligaments themselves; therefore, when the arc of motion of a joint is carried beyond the normal range, a small fracture

occurs more often than a tearing of ligaments. I believe that most sprains occur in the mind of the doctor and not in the body of the patient. I believe that most sprains are fractures and that, if we have roentgenograms enough, in various positions, they will confirm this statement, as tiny fragments of bone can be demonstrated very often. These tiny fragments of bone break off more often than we think.

I might remind you that the leather hinges, which were used at one time on the barn door, were held in place by nails, and if the door were torn away from the side of the barn the wood would break off before the straps would tear.

I believe it is worth remembering that ligaments have more tensile strength than the bony prominences to which they are attached.

If we will study the cases carefully enough we will find that most of the sprained ankles are in reality fractures about the ankle. When in doubt, cases should be treated as fractures and not merely as lacerations of the ligaments about joints.

DR. RALPH G. CAROTHERS (Cincinnati, Ohio, closing): I feel highly honored that the shortest paper I ever read before the Southern Surgical Association has had so much discussion. Doctor Cohn brought in some old farm problems, and I will bring in the sea. A sailor will tell you that if a long rope is fastened between boats which are moving, that rope will snap in the middle before it will injure the spar to which it is attached; but if you have a close-coupled situation you are liable to pull half the boat off. You will probably snap the external ligament in which there is a lot of play, or, the other way, you may snap off the malleolus on the inner side.

Doctor Murray is right. I have only had two fresh cadavers. It is necessary to have a fresh specimen; you cannot wait until rigor mortis sets in. Most patients will tell you they heard or felt something "pop," whereas with an ordinary sprain they do not have that feeling, and one case looks as bad as the other when they come in.

MASSIVE REPAIRS OF BURNS WITH THICK SPLIT-SKIN GRAFTS *

EMERGENCY "DRESSINGS" WITH HOMOGRAFTS

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AND

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THE REPAIR of massive burns with thick split-skin grafts as may be seen in the illustrations is the main subject of this report. But because of new interest stimulated by a realization of the numbers of burns that may occur in combatants and civilians, and queries such as by Dr. Walters in the discussion, it has seemed possibly worth while to summarize, again, the procedures that have already been found of value in repairing a good-sized series of deep burns.

One fundamental of extreme importance is the general care of each individual patient and the avoidance of pain. Burns seem so terrible to most people, and even more so with women and children, subject to them from military attack, that a new dread is formed, and a point of morale comes up for the military forces as well as the civilian. This may be one of weakness in general, but it might be strengthened if it could be made known that burns and their deformities can and will be taken care of. This point of morale must be important, also, in the enemies' eyes, or there would not be so much effort on burn-producing tactics. Besides the agony at the time of the burn, there is an added amount of it, if the patient does survive, when the wounds granulate and new nerve endings form.

Other summaries of this work have been made,[1-14] and quotations here are from them. While it is recognized that little of the good that might be wished for has been accomplished, it still seems best to start from what is already known. There is vast room for improvement, but possibly the most good for the individual will come from hard work, cleanliness, gentleness and simplification of effort. The expected new instances of burns will undoubtedly stimulate investigation as to their prevention, as to the most direct care for the patient immediately after the burn, and subsequently in relieving deformity. The pathology may be slightly different in burns from different causes, but the methods that have been found successful in repairing the resultant wounds in civil life can be applied to military casualties.

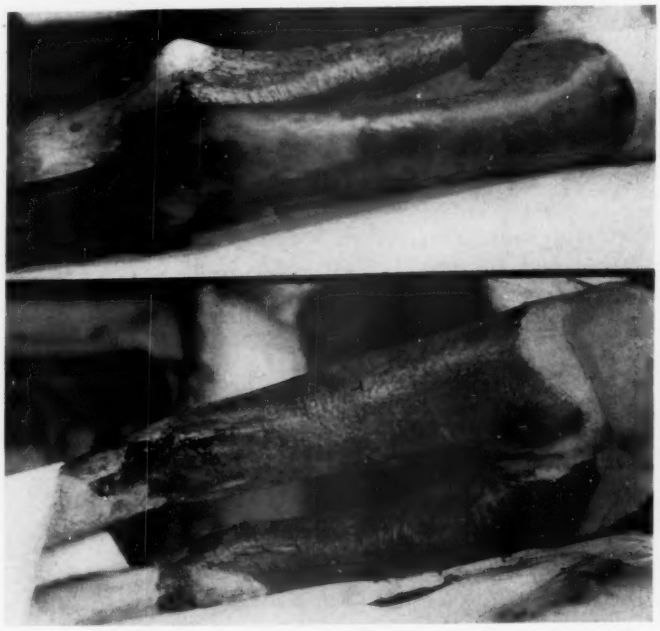
At the present time, with careful removal of grafts, so that prompt healing of the donor sites occurs, most patients can supply enough skin for their repair. As many as five "crops" of thick split-grafts have been taken from

* Presented by motion pictures before the Southern Surgical Association, Pinehurst, N. C., December 9–11, 1941.

the same donor area, 220 square inches have been transferred at one time, and 600 square inches have been grafted in a single patient (Figs. 1–4). As interest in the subject becomes more widespread, and as the possibilities of repair with thick split-grafts are recognized, new authors appear with worth while contributions, but often with the introduction of new terminology, and sometimes without realizing what already has been accomplished.

"When the full thickness of the skin is destroyed by a burn over a large area, an open wound results, and, unless there is early replacement of the lost skin by skin grafting, healing will occur by contracture of adjacent tissue and by 'scar' epithelium, or permanent healing may never occur (Fig. 4).

A.



B.

FIG. 1.—(A and B) Total loss of skin of both thighs and buttocks. Twenty-six large split-homografts from 26 donors used as "emergency dressings" before any autografts were made; thought to be life-saving in this instance. Different grafts persisted from three to 11 weeks.

Care of Open Wounds.—"Almost any treatment that promises as little work as possible is apt to become popular; but, so far, no application has been found that will produce normal skin and, when it is claimed that a certain preparation will insure complete healing without scarring, it is apparently not realized how healing occurs in superficial and in full-thickness losses of skin.

"If there is rapid healing and return to function following a burn without much scarring or deformity, this simply means that the full-thickness of

the skin has not been lost, and that regeneration has occurred from the deep glands in the derma, much the same as occurs in the donor site of a thick split-graft.

"It has been observed that these struggling cells are easily killed by chemical, bacterial, or mechanical trauma. Therefore, it appears that cleanliness,

C. D.

FIG. 1.—(C and D) Total restoration of function, five operations. 600 square inches of skin taken from back and abdomen—four "crops" from same areas, and one "crop" 19 days after the preceding one. Scars on donor sites hardly noticeable. Donor sites on back inadvertently cut off in the reproduction.

protection, and the avoidance of strong chemicals will best promote this type of healing, and these objects of treatment seem to have stood the test of time."[13]

Open Surgical Drainage.—This is the essence of local treatment, using soap and water and saline dressings or saline baths (Fig. 8). Chemotherapy is added to this, and sulfadiazine or other sulfa-drugs are sprinkled on the area before saline packs or other dressings are applied. The total dose of the drug per 24 hours, according to Perrin Long, should not be over 15 Gm. a day for an adult. Dressings may be kept wet, or open irrigations carried out with a 1 to 2 per cent suspension of sulfanilamide.

The object, besides saving life, is to get the areas clean quickly, so that skin grafts can be applied before contractures have occurred, and before debilitation and pain have developed beyond control (Figs. 1, 2, 4, 8 and 9). When wounds are clean and free of cellulitis, the wet packs may be discontinued. The wounds are still cleaned at each dressing, and are sprinkled with sulfanilamide, and wrapped firmly with fine-mesh gauze containing sulfadrugs in an ointment or aquaphor-like base, or an antiseptic ointment such as merthiolate. The wet dressings are changed at least every 24 hours, but

E.

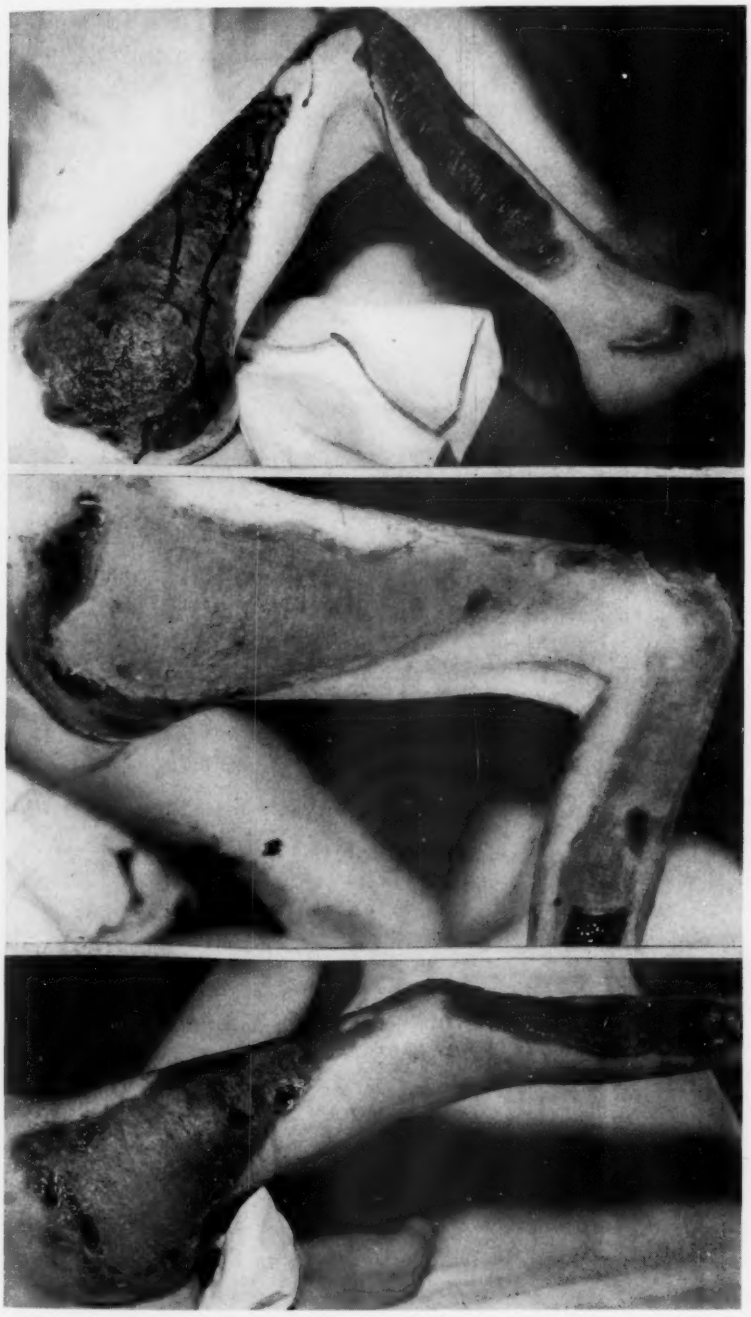
F.

FIG. 1.—(E and F) Laborious, but necessary, method of dressing, to insure growth of grafts and healing of donor sites. Fine-mesh gauze roll has "snubbed" grafts in place.

the wounds may go longer with the grease-gauze dressing. Any proven advance in chemical or biologic cleaning of wounds can be added to this general outline, but the important point is to recognize that mechanical cleansing and drainage are essential for any plan and, also, that innumerable antiseptics will be recommended.

Fine-Mesh Gauze.—This is a fundamental in dressing all raw wounds (Figs. 1 and 7). The mesh of this gauze is No. 44, and one or two layers of it are placed next to all open wounds, so that granulations will not grow up through the coarse meshes of overlying surgical gauze, stick, and cause pain.

FIG. 2.—(A) Total burn of hand and forearm. Patient intractable to the point of having had amputation considered. (B) Total restoration with split-grafts, without repairing deformity. One operation. Performed with autografts at same time leg was covered with homografts from father. (C) Completely healed, only two operations, with his own grafts from the back and abdomen. Hand opened out and further grafting at second operation, when leg was covered with his own grafts. (D) Donor site of homografts on the father.



E.

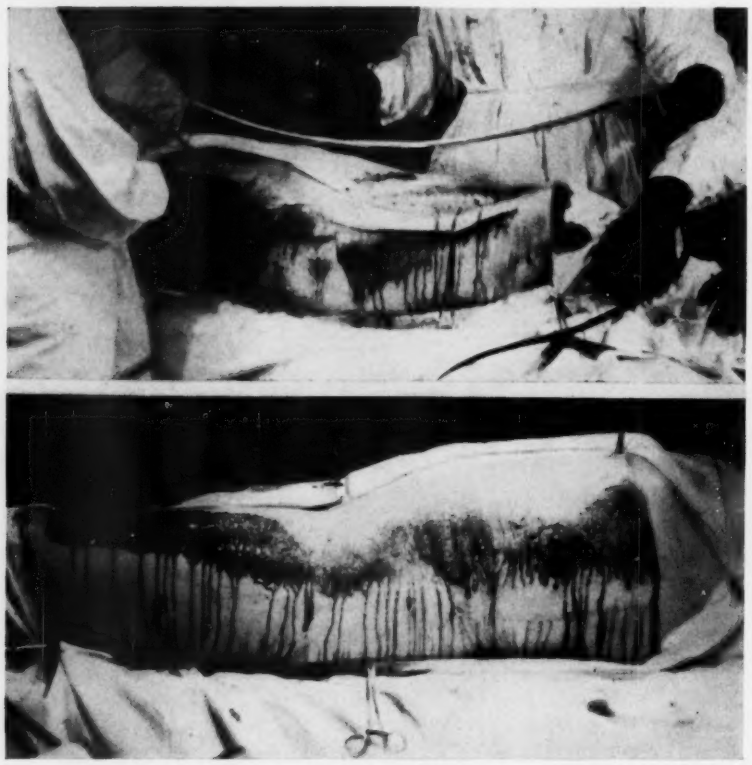
F.

G.

FIG. 2.—(E) Leg of same patient. Ninety degree flexion deformity from secondary contracture. Death may occur in this stage, and the work of cleansing the areas and getting patient ready for operation, at times, seems insurmountable. (F) Leg "dressed" in split-homografts from father. Complete "take" and coverage; three weeks postoperative. (G) Homografts still present after six weeks, but beginning to melt away. Improvement can be measured by the fact that the patient has opened his 90° flexion deformity spontaneously. Whole area restored later, in one operation, with thick split-grafts from back, as shown in Figure 2 C.

It may be used as it comes for wet dressings, or have greases incorporated in it. One of the easiest ways is to have the ointment soaked in a full roll, store it that way, and use it from the roll, especially for extremities. Plain vaseline is not used because of a tendency to macerate, but almost any powder in vaseline, sulfanilamide, xeroform, scarlet red, boric, *etc.*, will prevent maceration of the skin.

A.



B.

FIG. 3.—Cutting large, thick split-grafts. (A) Very large grafts can be obtained from large patients. One graft, 36 inches long and four to five inches wide is seen, held above the patient. Another one is being detached, 18 inches long and five inches wide. (B) Donor site of a single large thick split-graft. Total amount removed at this operation, 220 square inches. Same patient as Figure 4.

Firm Pressure or Elastic Dressing.—This may be of great advantage; and discolored, edematous granulations may be flattened out into a firm, bright red surface without cauterizing or cutting them away. Cotton mechanic's waste may be incorporated in the dressing as a medium of pressure (Figs. 1 and 7).

Saline Bath.—This bath of all or part of the body has often been a life-saving measure; many patients are extremely grateful for the bath and realize their first comfort in it. The bath is not easy to manipulate (not even possible some places), but its technic is not as difficult as it sounds, and it may

be the easiest way to get the cleansing done. The water is kept comfortably warm, up to 5 per cent salt may be used and cleanliness but not sterility is aimed at. Soap cleansing and gentle débridement of dead tissue can be done with less pain when the patient is in the bath. If there is any unfavorable

A. B.

FIG. 4.—(A and B) Repair of huge burn scars and ulcers of legs with thick split-skin grafts; transferring 220 square inches at one operation. Same patient as Figure 3.

reaction, it is omitted. The bath may have the important result, that most secondary contractures will be straightened out by the voluntary effort of the patient without the use of traction or restraints (Fig. 8).

When out of the bath, further fine-mesh gauze dressings, either wet or greased, are used, and a covered bed makes nursing easier. Overhead lights may supply warmth, but too much heat is not advisable.

Large open wounds seem impossible to sterilize, but careful evaluation of the general condition and of the gross appearance of the granulations, sur-

rounding tissues and the absence of cellulitis usually suffices for the determination of the time for operation, and many deep burns are ready for grafting in three weeks' time. In them, general debilitation is worse; the fluid loss is, of course, greater; there is more chance of deformity and more chance of damaging some underlying structure in the operation, so that a very large wound, from the possibilities of repair, does present many of its own problems not so troublesome in small wounds.

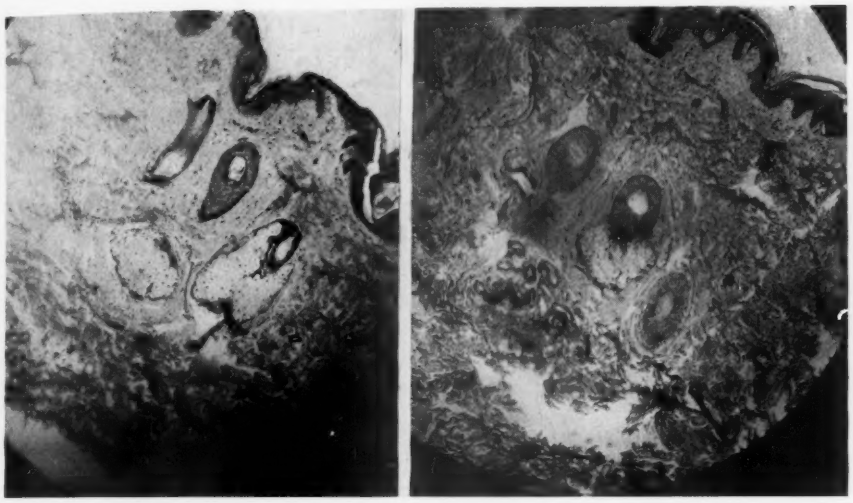
Bacillus pyocyaneus is very frequent in large wounds, especially if they have been uncleaned over a long period, and though it does not appear to hurt the patient or the wound, it is exceedingly bad for skin grafts. If the open surgical drainage and sulfanilamide does not suffice, then being sure to get rid of all caked débris with soap, water and forceps, and the application, one or two times a day, of 5 per cent gentian violet or mercurial antiseptic may help.

Infected tannic acid membranes occur in practically all deep burns where this treatment has been used, and the disposal of the membrane and control of the infection is always a problem. The membrane may be opened in several places and any loose areas detached and then powdered sulfa-drugs and packs used as outlined above, or the drug in ointment applied, if there is not too much discharge and cellulitis. Open surgical drainage plus chemotherapy, in other words, is again the treatment. If one thinks that toxins might be released by the soaking of the membrane, hypertonic saline could be used. If the tannic membrane is clean, as it may be on a superficial part of the burn, it may as well be left until it drops off, even if this takes several weeks, because cutting or pulling it off only disturbs the healing.

While on the subject of infected tannic membranes, it may be well to state that burns of the hands and face and the genitalia do best with open surgical drainage treatment from the start. Any treatment any place in the body should be preceded by careful cleansing with soap and water, débridement, and ether as a solvent if necessary, and all burns could be treated with open surgical drainage and chemotherapy. This is important in the areas mentioned; because the hands should be allowed movement and grafted early; the face seems to heal best and rapidly with open drainage, and there is not so much chance of damage to the eyes; and the genitalia almost always require open drainage anyway, if the burn is deep.

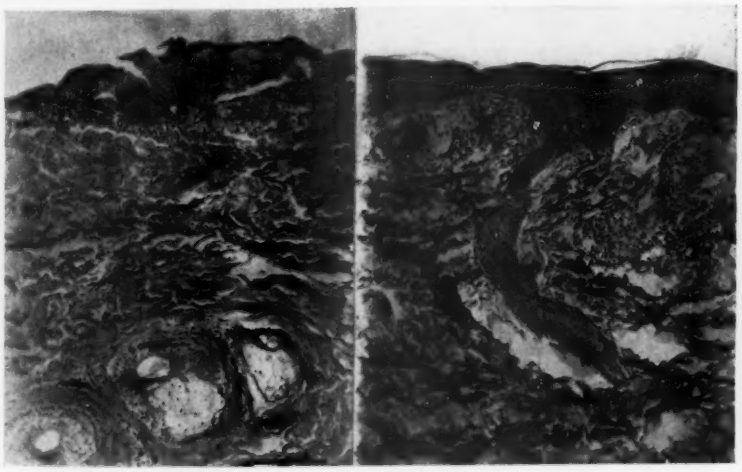
The general condition of the patient is directly reflected in the wounds, and, of course, should be considered primarily in all instances. Gentleness in all manipulations is always an essential of the care. In this stage, anemia is usually present, and frequent whole-blood transfusions may be necessary. Adequate diet, protein, and vitamin intake are important. For infection that is not controlled with the local treatment, sulfanilamide is given by mouth as indicated.

Thick split-skin grafts of from one-half to three-fourths of the thickness of the whole-skin are the most useful in making repairs of raw surfaces. These could be called "thick Ollier-Thiersch grafts" but the original Ollier-Thiersch



A. B.

FIG. 5.—(A) Thick split-graft of about three-fourths of the full-thickness of the skin. (B) Full-thickness of the same skin—same magnification. (Ollier-Thiersch grafts were supposed to be cut clear up, just under the epidermis.)



A. B.

FIG. 6.—(A) Two-day-old donor site of thick split-graft, with no surface epithelium. (B) Same donor site, six days after thick split-graft had been removed, showing complete surface coverage, with squamous epithelium, "dedifferentiated" from the deep parts of the hair follicles.

graft was cut just through the papillary layer of the epidermis, which makes it very thin without any derma. However, the pad of derma happens to be a most important part of a skin graft and to avoid confusion, the term "thick split-graft" seems most descriptive (Fig. 5).

When large areas are to be covered, it is necessary to obtain large thick grafts without cutting entirely through the derma, so that healing of the donor site can occur rapidly, without leaving any further defect. The deep glands

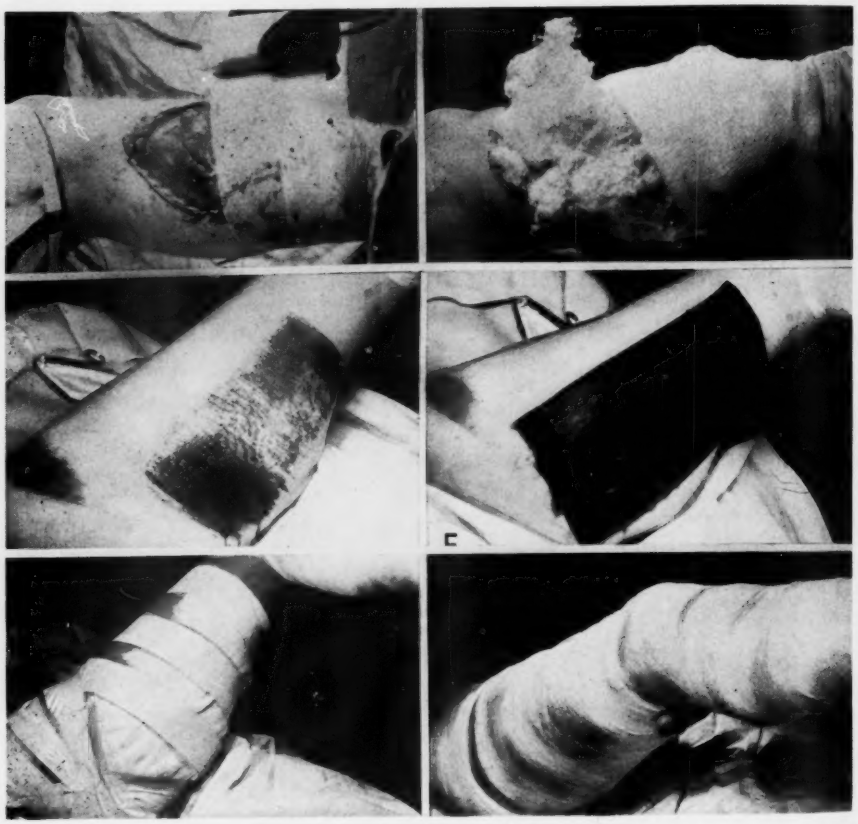


FIG. 7.—(A) Fine-mesh roller bandage of 4 per cent sulfanilamide in an aquaphor-like base. Split-graft sewed on; overlapping the edges and mattressed over surface. (B) Cotton mechanic's waste as a medium of pressure. (C) Donor site of thick split-graft, with derma intact. (D) Fine-mesh scarlet red gauze just over the defect. (E) Donor site carefully protected from mechanical, bacterial and chemical trauma. (F) Whole leg, with firm pressure dressing and joints immobilized.

left behind in the derma of the donor site "dedifferentiate" into squamous epithelium, and cover the surface in from six to eight days. This is shown, microscopically, in Figure 6. It is an interesting study in wound healing and is comparable to the healing of superficial burns. It is probable that this healing occurs from the hair follicles exclusively.

There must be careful protection of the donor sites, and these are dressed with fine-mesh 5 per cent scarlet red ointment gauze, or other suitable oint-

ment, and are supported carefully with adhesive to avoid mechanical, bacterial and chemical trauma (Fig. 7). The dressing becomes soaked with serum, but is left on from 10–12 days, at which time it should come away and complete healing have occurred. In excessively large removals this added loss should be taken into consideration and whole blood transfusions are often required. If the graft has been cut through the derma, or if chemical, bacterial or mechanical trauma has occurred, many new epithelial cells are killed and healing is delayed from three to ten weeks. This is comparable to an infected tannic acid membrane on a superficial burn.

Cutting Thick Split-Skin Grafts.—The most necessary equipment is a very sharp long knife of the amputation variety. Large grafts may be cut rapidly, and the larger they are, the more easily they may be applied; grafts up to 5x18 inches may be obtained from suitable thighs; even longer ones can be obtained from some patients (Figs. 3 and 4). With some practice, the thickness can be easily graduated with free hand-cutting, and the thickness of the graft should depend on the relative full-thickness of the skin of the area. This thickness varies greatly in different parts of the body and in different patients, so that a set-thickness cannot be described for this graft. The essential thing is that it be cut thick, but not too thick, to prevent the donor site from healing promptly.

The derma of the skin of the back is much thicker than anywhere else, and for this reason, it is one of the best sources. Grafts for most raw surfaces, taken from the back, do not have to be cut over one-fourth to one-half the thickness of the skin, and by being careful, as many as five "crops" have been obtained from the same donor area when free-hand cutting has been done; and a second "crop" has been taken as early as 19 days after a previous one. Thick dermatome grafts do not permit this.

With mechanical aids, such as the dermatome, the suction retractor, or by elevation of the skin with large tenacula, fairly large grafts may be cut, even from the abdomen, but care has to be exercised not to cut through the derma. The dermatome may be an advantage for one who is not used to removing split-grafts free-hand, and in children when the thick skin of the back is available. The free-hand method is the fastest method, and any time saved is often a great advantage.

Application of Thick Split-Skin Grafts.—These grafts are applied to the prepared area, and held at about normal skin tension with No. 000 silk sutures all around and with multiple mattressing sutures over the surface. In suitable areas, the grafts may be spread out and then "snubbed" in place with a sterile fine-mesh roller bandage (Figs. 1 and 7).

If the granulations are new, flat, not edematous, and are otherwise bright red and healthy, the graft may be placed right on them. It is usually better to carefully shave the granulations down to a smooth, yellow base with a large sharp knife and then apply the grafts. The granulations are *never scraped* away. If cutting them over a large area will cause too much blood loss, it is

omitted. It is probable that a light dusting of sulfanilamide over the wound before the graft is applied is worth while, and it apparently does not hinder the growth of the graft.

Pressure Dressings on Grafts.—A single layer of fine-mesh gauze with 4 per cent sulfanilamide ointment, or other suitable greased gauze (merthiolate,

A. B. C.

FIG. 8.—(A) Open surgical drainage as primary treatment of deep burns. Saline bath and fine-mesh gauze dressings as outlined. (Saline low in tub for picture.) (B) Total loss of skin from thighs. (C) Restoration left, one operation, with thick split-graft, requiring general anesthesia. Restoration right, one operation, with small, deep grafts, with local anesthesia. This leg was six months behind the left one in final recovery.

4 per cent xeroform, or scarlet red) is placed smoothly over the graft and pressure is obtained over the area with mechanic's cotton waste, bound on firmly with heavy gauze rolls. The application of pressure to the dressings is a fundamental, and as important as any other operative step. This cotton mechanic's waste can almost entirely replace marine sponges as a medium

of pressure; it is better in most places, and is a great deal cheaper. A good grade is used, and is obtained from plumber supply sources, as none of the gauze companies prepare it. (If contamination is thought to be marked, a wet pressure dressing can be used.) (Figs. 1 and 7.)

Subsequent Care of the Graft.—If satisfactory, the dressing is to remain from four to six days. It can then be changed, the sutures removed, and the excess edges trimmed away. If the area is clean, the same type of dressing is reapplied and then changed as necessary. Blebs are trimmed away, hematomata are opened and, if there is infection, sulfanilamide applied locally, and wet (but firm pressure) dressings are applied and changed each day. Later on the greased gauze resumed.

Full-thickness grafts are not placed over large raw surfaces because the size required is prohibitive, and the "take" of a full-thickness dissected graft is not as certain in contaminated fields as that of the split-graft. This graft is used in late deformities, especially for areas not covered by clothing. For this reason, it is important to save a donor site on badly burned patients, if possible, so that smooth full-thickness grafts may be obtained when final operations are to be undertaken about the face and neck.

HOMOGRAFTS AS EMERGENCY "DRESSING" FOR WOUNDS

It may be a life-saving process to go to the trouble of applying large sheets of split-homografts in patients who cannot stand a long operative procedure, and who are "slipping" daily from debilitation and pain. Homografts take almost as well as autografts, and survive from three to ten weeks. During this period, the patient is given a respite from pain and dressings, his general condition picks up, and there is a stimulus to his own epithelization, so that complete healing even may occur after absorption of the grafts. This notable increase in wound healing has caused some observers to think that homografts survive permanently. The grafts absorb in a rather clean fashion, just fading away from the third week on, without infection usually, and leaving a clean granulating base (Fig. 2).

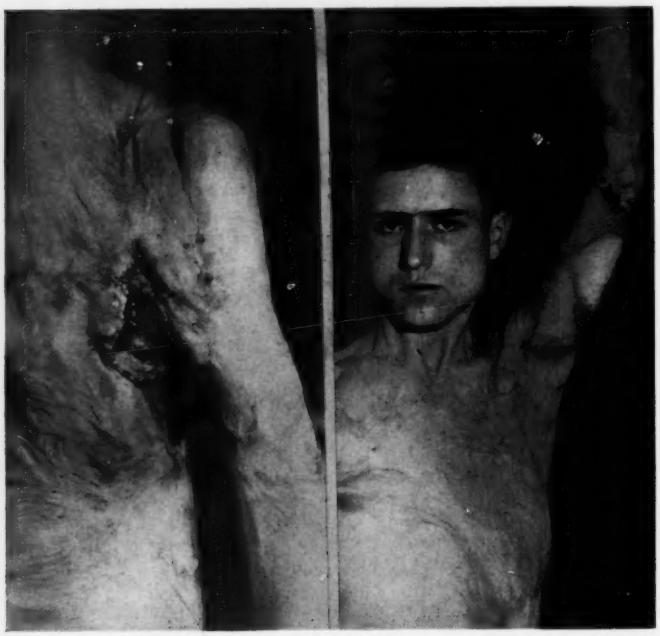
There does not seem to be any relation of the "take" of a homograft to the blood group, even though the blood has been grouped down through the M. and N. groups. If these grafts could be gotten to survive, one of the greatest problems in plastic surgery would be solved (Fig. 1). Homografts in identical twins have been shown to survive permanently, experimentally, and if a twin were burned, homografts from the other twin could be used, with a good chance of their surviving.

Early grafting of burns and other wounds. It is assumed that most observers believe that the earliest possible grafting of open wounds is advisable and that the primary excision and grafting of burns may be applicable occasionally.

Repairs of Contractions.—The repair of fresh wounds that have not had time to contract cannot be completely separated from those that have con-

A. B.

FIG. 9.—(A) Unhealed burn after several months with dirty, crusty wounds, and consequent intractable pain. Dirty, inadequate coarse-mesh gauze dressing. (B) Cleaned up. Grafting of raw areas first, to control pain and infection. Later corrections with more free skin grafts.



A. B.

FIG. 10.—(A) Contracted axilla opened because of a dirty sinus, deep in the scar. (B) Total restoration of function having persisted through an 11-year growing period—221 square inches of thick split-grafts transferred to cover chest, back, arm and entire axillary region. Two graft operations.

tracted, as this, of course, depends on when the patient is first seen or how soon he can stand operation. The open wound requires just grafting, while the contracted one requires relaxation and restoration of parts of their normal positions. Sometimes, of course, both have to be done, but if there is an open, dirty wound over part of an area, and a flexion deformity along with it, it is often best to obtain healing first by grafting the open area and considering the deformity later, rather than opening into a clean flexion area through a dirty surface, or a dirty sinus may be opened and cleaned up before any grafting is attempted. (Figs. 4, 9 and 10.)

The patients illustrated are not so much case reports, as to show examples of the various points listed in the paper. Long histories and details are omitted because the original premise is thought to be true—that these repairs of massive burns can be undertaken successfully and in a fairly acceptable routine manner, and that the laborious use of full-thickness grafts and pedicle-flaps can be avoided in many instances.

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[4] The Repair of Surface Defects, from Burns and Other Causes, with Thick Split-Skin Grafts. South. Med. Jour., **29**, 408, 1935.
[5] A Study of Ulcerations of the Lower Extremity and Their Repair with Thick Split-Skin Grafts. Surg., Gynec., and Obstet., **63**, 331, 1936.
[6] Homografting of Skin: Report of Success in Identical Twins. Surgery, **1**, 559, 1937.
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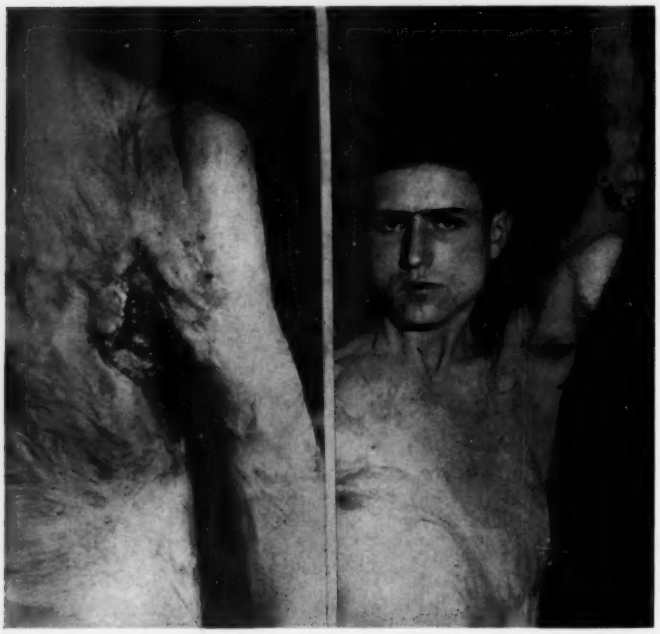

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I would like to ask Doctor Brown whether the great increase in the size of the denuded area caused by cutting these large grafts has had any upsetting effect on the patient.

DR. WALTMAN WALTERS (Rochester, Minn.): Would it be possible for Doctor Brown to speak a little about the management of these cases, for the benefit of those of us who do not know so much about plastic surgery. If he could do this I believe it would be very welcome.

TRENDS IN SURGERY*

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LOUISVILLE, KY.

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THE HUMAN RACE has through the ages looked for some panacea which would bring relief for all its ills. This applies most particularly to physical defects, deformities and disease. Each age found its best savants and students so engaged.

The earlier advances were very slow—the result of the difficulties of transportation and the lack of contacts. Century after century passed, each adding but limited knowledge. Its gradual growth was more or less constant. Always the search began with matter; its formation, its elements and their changes, which were most impressive not only to the early investigators but continue until this day. Each individual searched in the particular field which most impressed him. To see the mind of a child unfold even at present is remarkable, and the difference in the alertness, the quickness of perception and tenacity of memory in some children as compared with the dulness, slow perception and inability to grasp ideas in others, at once brings the question of why this is true. So in adults every mind will produce better results if directed in its natural bent. The psychologists have long recognized this fact. Every man who handles large groups of individuals notes and employs this idea to get the best results.

First, in the order of development, came the effort to obtain physical comfort. Food was necessary to sustain life and the search for it is noted in every form of organism from the lowest and smallest to the largest and most complicated.

Every outside influence upon life processes naturally impressed the individual. The materials contacted brought matter to his attention. Land, sea, and the simpler elements, water, air, fire, and the physical change in their form and structure excited the curiosity of man. Light and darkness, heat and cold, each brought wonder and the desire for knowledge to the active brain. It is not possible that all these things were taken by everyone as a matter of course. There were bound to be some who desired an explanation of these phenomena.

The contest with the elements resulted in the formation of communities for defense and protection. It is not remarkable how slow was the increase in knowledge, but how wonderful and gradual was its development. It is the general belief that facts reach the individual and the community when they are prepared to receive the information.

This discourse is held to call your attention to medical progress through

* Read before the Southern Surgical Association, Pinehurst, N. C., December 9–11, 1941.

the era of mythology and tradition, mysticism and fact, the darkness and confusion of the middle ages, the progress and illumination of the later days, the errors in reasoning and conclusions in many instances, and the manner in which each increase in learning unfolds. Much stumbling occurred in every branch of science, but this brought, in every age, demonstration and proof of the correctness of certain ideas.

We desire only to mention the early writers on medicine, alchemy, chemistry, anatomy, physiology and histology, to make you realize just how much we owe to these investigators.

"Reading maketh a full man, conference a ready man, and writing an exact man." Could one realize the increase in knowledge contributed by each generation as time progresses, the result would be surprising. Excursions through the literature always bring to the reader an admiration for the early investigators. Our study here of the early years must naturally be sketchy and only mentioned to call your attention to the outstanding facts established as the final result. Much of the knowledge has been obtained by accident after prolonged hours of study. The description given by Kekulé of how the benzene ring came before his consciousness in a half dream state after a long conference with his friend, Mueller, and of its later confirmation in the light of cold reason, is illuminating. The same is true of the accidental discovery by Sir William Ramsay of the beautiful mauve color which resulted when he was about to throw into the discard an ugly, muddy material at the end of a day's work, but decided to pour alcohol into the flask when suddenly the beautiful color appeared. From this incident came the aniline dyes and the many chemical combinations including the sulfonamide group so valuable in pneumonia and other infections.

In my search of the literature it has been necessary to quote freely from The Doctor in History, by Howard W. Haggard, Yale University Press, 1934. I have received much information and wish to give the author and the publishers my thanks for the permission. Credit must be given also to Dr. Henry E. Sigerist, the editor of American Medicine, and to its publisher, Yale University Press, 1934. In the first paragraph of his preface Haggard says: "Daudet, presumably with a view to their moral sophistication, wrote Sapho for his children to read when they were twenty-one. Chesterfield wrote his letters in the interest of his son's social elegance. I know nothing of the effect on Daudet's children; Chesterfield's son did not appear to benefit. Nevertheless, hopeful, as parents will be, I have followed the example and written this book for my children. Not, let me hasten to say, for their morals or their manners. Perhaps it is a reflection of changing times, or possibly merely of my own interests, that I am frankly concerned less with these matters than I am with some other aspects of their education and their health —especially their health. What I have tried to write for them is a history of health."

Credit must be given to the many writers and historians for what occurred in early Egyptian and Greek medicine. The very early stories are surrounded

by uncertainty and are full of legendary and at times improbable statements. Therefore, they have largely been omitted and we have attempted to include only written statements which have the semblance of truth.

It is not surprising that in the early years for a number of centuries the Church was closely involved with medicine because it was far advanced in education and interested in human welfare. For a time the clerics practically controlled the practice of medicine.

As superstition lessened under advancing knowledge religion increased in power and the prelates of the Church were the foremost students of that period. It was the natural function of the Church to succor the sick and care for the indigent. Hence, men interested in medicine and in surgery sought knowledge where it was most advanced. The early Egyptians were learned in medical lore, and from Arabia and Persia came rumors of wealth and wonderful cures of disease, finally reaching Greece and Rome. The conditions led to attempts by one country to overcome another and to obtain its wealth and its knowledge. Then wars brought more information and developed in addition to medical lore the necessary knowledge of surgery to care for the injured soldiers. Epidemics and plagues resulted, giving a stimulus to medical search for prevention and cure. The names so engaged are legion. Credit is given to Hippocrates, of Cos, for bringing medicine from speculation and superstition to the realm of fact. He not only contributed to the history and symptoms of disease, but recorded the history of his cases and gave methods for operation upon surgical lesions. In his writings he describes the Hippocratic facies, so well known to all practitioners. Naturally he was not so positive as Galen and others who had more facts to guide them. The value of recording symptoms, the time of their appearance, and the changes occurring with the methods of treatment first came into use, and to-day the value of the history of the patient is recognized. It has become well established in the recognition of a hospital as meeting the requirements for the instruction of interns, house physicians and surgeons.

"Hippocrates with his honesty, his insistence upon clear reasoning, and upon observation of facts, rather than speculation expresses the ideal of our modern medicine. In the early years studies in anatomy were not easy of access because of prejudice against disturbing the dead, particularly in Egypt, and cadavers could not be obtained. Occasionally skeletons were found for the study of osteology. The Greek army after the death of Philip, of Macedon, under the command of his son, Alexander the Great, completed the conquest of Persia and the whole Eastern world as far as India." He founded the city of Alexandria and placed the first Ptolemy as its ruler. "With the army went scientists to collect information from every country for Aristotle's great books on natural history." A great museum and library were erected at Alexandria, and a vast number of manuscripts of Greek scholars were collected. Alexandria became famous as the great seat of learning in all branches of study including medicine. "People came from every part of the world, beliefs were mingled, old religions were discarded and new ones grew up."

Here Herophilus made dissections of animals and wrote a textbook of anatomy which was really a scroll, a hand-written manuscript. Following the conquest of Alexandria by the Persians under Cambyses, Imhotep, with a reputation increasing for 2,000 years after his death, had become a god—the Egyptian God of Healing and Medicine. "The temples where he was worshipped were in a way hospitals and were schools of medicine and magic." "These priests wrote on papyrus of the diseases they saw and the treatment they gave." "These temple papyri were the first written records of medicine —the first medical books." "The Greeks were open minded, respected the gods of all people but gave none a profound reverence." "When at length their sailors and merchants came to Egypt, they saw in Imhotep not a rival deity but their own God under a different name. They called him Imuthes and linked his name with their own God of Healing, Æsculapius." According to Haggard, "Egypt had reached the peak of its civilization and was declining, dying." Its art, its architecture, its literature, had become formal—unchanging.

"But this country of tombs and mummies became with the passage of centuries a vast storehouse of wisdom from which other and younger civilizations, more progressive, were to learn something of the mysteries of life and death, of health and disease."

The Anatomic Era began with Herophilus (335–280 B.C.) and continued to the time of John Hunter (1728–1793 A.D.); during the greater part of this time but little progress was made in anatomic studies because of the difficulty in obtaining dissecting material. This limited the number of students of anatomy. It was not until the 16th century that Andreas Vesalius wrote the first true human anatomy, based on actual dissections, yet all the teachers of anatomy said that it could not be correct because it differed from Galen. Some went out of their way to irritate and embarrass him. He became so indignant that he burned his manuscript, quit anatomy, left Padua, and became physician to Emperor Charles V. While isolated at the court some mild inquiries were made to see if he were correct, and it was found that he was. Vesalius was soon forgotten, a fact which caused great disappointment in his life, entirely undeserved, yet not so tragic as the treatment accorded Ignatz Philipp Semmelweis in Vienna.

For years physicians in England and in France took the position that it was beneath their dignity to be asked to do any of the menial work in the care of the sick. Their attitude was that their superior knowledge of disease, and their diagnostic acumen, placed them in a class by themselves. Their College of Physicians would not permit a barber surgeon or surgeon to be elected to membership. "The physicians looked with contempt upon surgeons; few educated men cared to take up this branch of medical study." "The lack of knowledge of Latin, because they had not studied in the University, placed them as surgeons of the short robe." Paré, who accomplished some remarkable feats in surgery, belonged to this group. He was one of the first to combat the idea that the surgeon was a menial and inferior to the physician.

In 1536 Paré went with Marshal Montejan as his regimental surgeon. "I was at that time," says Paré, "an untried soldier; I had not yet seen wounds made by gunshot at the first dressing. It is true that I had read in Jean Di Vigo that wounds made by firearms were poisoned wounds, because of the powder, and for their cure he commanded to cauterize them with oil of elder, scalding hot, in which should be mixed a little theriac; knowing that such a thing would bring great pain to the patient, I wished to know first how the other surgeons did for the first dressing, of whom I took courage to do as they did. At last my oil lacked, and I was constrained to apply in its place a digestive made of the yolk of eggs, oil of roses, and turpentine. That night I could not sleep at my ease, fearing that by lack of cauterization I should find the wounded, upon whom I had failed to put the oil, dead or poisoned, which made me arise early to visit them, where beyond my hope I found those upon whom I had not put the oil feeling little pain, their wounds without inflammation or swelling, having rested fairly well throughout the night; the others, to whom I had applied the boiling oil, I found feverish, with great pain and swelling about their wounds. Then I resolved, with myself, never more to burn thus cruelly poor men wounded with gunshot."

Paré was a born surgeon, with a temperament suited to his calling. As shown in the above narrative told by himself, he had the milk of human kindness in his soul and a desire to serve. He followed the leaders as far as his judgment permitted but did not hesitate to change his plan of treatment when the need arose. A surgeon never soars to great heights when bound by a rule of thumb. He always remains an imitator and not a master of his art.

Paré had surgical instincts and rare judgment; he restored the use of the ligature to control hemorrhage, which had been used centuries before by the Romans but was discontinued. By this method secondary hemorrhage was less frequent than from the cautery or boiling oil, and it is the safest method for this purpose today.

William Harvey (1578–1657), a graduate of Cambridge, went to Padua and received his Doctorate in Medicine in 1602. He made a calculation, in 1618, that two ounces of blood passed through the heart with each beat: "72x2 ounces, 144 ounces a minute; 540 pounds an hour." "Absurd to think that the body produced that much blood. There could be only one answer; the blood circulated." In the seventeenth century came the first transfusion of blood, and considerable debate occurred as to what would happen to the character of the recipient. At present more interest is taken in the immediate result to the reaction, and the incompatibility. In those early days there was no knowledge of microbic infection with suppurative organisms; nor was lues, the serious social evil, then discussed publicly in the forum or drawing room. Men said that Harvey was wrong because Galen found it otherwise. On the other hand, Servetus called attention to Galen's mistake in this matter, pointing out what he thought errors in religion, a very unwise thing to do. "Servetus was burned to death in 1553." The work of Harvey, and the two Hunters somewhat later, determined opinion on surgery of the

blood vessels and opened a wide field in every portion of the body. The reparative power of the blood vessels is not surpassed by any structure, not even the peritoneum nor the lung. Stab wounds of the heart closed by suture have been known to heal completely within 17 hours, the patient dying of a concurrent injury. One by one every field of the body has come within the reach of surgery of to-day. The abdominal aorta has been opened in planned operations a number of times, not often with success but enough to demonstrate its possibility. Death may occur from other emboli and the wound in the aorta is found healed. Embolectomy of smaller vessels has been successful. Sutures of arteries, in their continuity, after traumatic rupture have been safely completed after repeated failures, as was the case in the first vesicovaginal fistula which made James Marion Sims famous. The best men in all ages have failed, and so reported, but continued their efforts until their task was successful. Clots were removed from arteries in their course, both from peripheral and pulmonary vessels with a diminishing mortality. Matas, by his aneurysmorrhaphy, in 1888, systematized it in 1902: thus he made a great contribution to the surgery of the vessels. By this operation it was hoped to restore the circulation without impairment of the nourishment of the limb.

The studies of Pasteur, Koch, Behring and others of microbes and their place in fermentation and suppuration opened a new line of thought. The views expressed by the bacteriologists that minute living organisms caused both fermentation and suppuration in wounds were not at once accepted. It was my good fortune, immediately upon graduation, to hear the debate on each side of this question. Joseph Lister was one of the first to accept this view as a fact and no longer a theory. He claimed that the only way to overcome this contamination was by the use of carbolic spray about the wound and in the air of the room. The hands of the surgeon and all of his assistants, with all others coming into contact with anything used in the operation, were placed in dilute carbolic solution after being thoroughly scrubbed. His paper was published in 1867, and during the next decade he gained considerable reputation and was knighted. His antiseptic method worked well but required too much paraphernalia. Mr. Lawson Tait soon proved that equally good results could be obtained by simple kitchen cleanliness. This method was promptly adopted by the whole medical profession. The proof of the correctness of the view that pus production in wounds resulted from bacteria was so apparent that the debate here rested on the question of whether the views of Lister or of Tait would prevail. Gerster's book came to my attention, and the younger men followed and accepted the idea that this was no longer a theory but a fact. We soon became converted to Tait's view of asepsis and found the results to be satisfactory.

Then American surgeons took the lead and made many new advances in technic, employing rubber gloves, and covering the head and face with a cotton hood, and showed fine records in new fields. There were some changes in operative methods and the preparation of the field from time to time. Soap, water and alcohol made preparation of the wound simple and satisfactory. It

was found in several clinics that too much scrubbing diminished the resistance of the skin, and this was given more care and less energy; because soap and water made the preparation too "sloppy" and at times left the patient wet, the trend simultaneously throughout the country was to employ a 3.5 per cent iodine solution. This method was time-saving and left the field dry, and was in vogue for a considerable time. Because of a few cases in children where the solution was too strong—producing blisters—70 per cent alcohol was substituted, with success. At the present time most clinics have adopted alcoholic solution of merthiolate for this purpose. During this period the progress in surgery in this country was remarkable.

On my first trip abroad, in 1900, Sir William Macewen, whom I consider one of the best surgeons of my acquaintance, used the same technic then in use here. In Edinburgh, a few hundred miles away, the contrast with the technic in the clinic of Sir John Anandale was noticeable. The latter was a fine surgeon of the old school who had not yet adopted the new methods. Macewen and Sir Victor Horsley, in London, using the same technic, were opening up cerebral surgery and by their observations were contributing much to the knowledge of the physiology of the brain.

On the continent I found the same high-grade type of work in Berne, where Dr. Theodore Kocher was undertaking the largest and most successful surgery on goiter, and it was a pleasure to watch him work. He used many silk ligatures in the neck, which I have never found it necessary to employ, but his results were excellent. There are some surgeons here who seem to be drifting back to the use of silk sutures instead of catgut, which has always served me so well. They may be correct but my experience makes it doubtful, and I should advise a change in the make of catgut, which will probably remove any objections they may have to its use for sutures or ligatures. There will probably be a number of minor changes in technic from time to time, but, in the main, the general trend is toward uniformity in practice, especially in this field, which has become greatly enlarged within recent years.

The greatest changes have occurred since 1900, when I found Macewen and Victor Horsley opening up new fields in cerebral surgery, and these changes have been remarkable. Notwithstanding the fact that a number of medical men of ability claimed that further advance would be only in the field of technic, it has been disproven by the increased knowledge of function in the different portions of the brain, and by the remarkable results in the treatment of tuberculosis. Moreover, it is true that a great increase in our knowledge of pulmonary diseases is the result of marked improvement in methods of roentgenologic examination. It appears that the progress continues about the same in every field of medicine.

A remarkable change followed the communication of Oliver Wendell Holmes on the contagiousness of puerperal fever, in which he made the statement that this disease was the result of microbic poison carried to the patient in childbirth. This contention was also made a little later, most vigorously, by Semmelweis, in Vienna. He so offended the obstetricians that he was

driven from Vienna, but in Budapest produced positive proof that he and Holmes were both correct. This was the most remarkable advance in obstetrics in a century.

The Dean of Gynecologic Surgery in the United States, Dr. Howard A. Kelly, contributed perhaps more than any other man to this field, and to surgery of the pelvic organs and the urinary tract. Kelly must be given due praise for the patience and persistence with which he worked for the methods of cystoscopy and ureteral catheterization. In addition to a very large surgical and gynecologic practice, he gave an immense amount of time to improvement of technical methods of operations in the pelvis and perineum. He has written the most valuable and elaborate treatises, beautifully illustrated by Max Brodel, and others, and acquired a wide reputation. In this work he was ably assisted by Thomas S. Cullen, Guy L. Hunter, Curtis F. Burnam, and other members of his staff. Doctor Kelly was the first American to recognize the value of the discovery of radium by Curie, with its wonderful possibilities, which, with the use of high-voltage roentgen rays, covers a large field in the treatment of skin, glandular diseases, and types of malignancy. It is often very effective.

One of the most important developments, and aids to both medicine and surgery, came when William Crookes, an English physicist, brought out the vacuum tube. It was looked upon as a useful means of instruction for students of electricity, and few could visualize its possibilities. The observations of Wilhelm Konrad Roentgen, in 1895, that "a piece of paper coated with certain metallic salts held in the light from a Crookes's tube the coating glowed with a curious phosphorescence." The glow continued when the paper was removed from the tube. "He held a piece of metal before the paper; a shadow was cast; he held his hand before it and saw what no one had ever seen before—the shadow of the bones of his hand." These rays affected photographic film, and pictures could be made of structures beneath the skin. These observations created a furor. Its practical use was not evaluated. The determination of lines of fracture and of the presence of foreign bodies in the esophagus, the trachea, lung and the gastro-intestinal tract and, subsequently, vesical stone, was a marked step forward.

Then it was that the impetuous operator of the roentgenologic department, in spite of Roentgen's advice that red lead paint be used to protect the operator against the rays, learned of the danger of burns from this source. Quite a number developed troublesome ulcers and these vascular disturbances became cancers. Sometimes the hero dies because of his search for knowledge, and his love of humanity. Coolidge and the radiation tube opened a vast territory for the benefit of mankind.

Stones in the gallbladder were soon found interesting, but only a small proportion were shown by the early technic. Graham and Cole by the use of dyes opened a still newer field in the determination of the function of the gallbladder and increased our knowledge. During these years of study, gastroenterology was clarified by the use of bismuth, and later barium, to visualize

these structures. The work in osteology continued, and with the dyes, a Bucky diaphragm, and intravenous injection of diadrast and uroselectin, renal lesions became an open book, including the ureter throughout its course, and the bladder. This recalls to my mind how we had to make a diagnosis of hydronephrosis, tuberculosis of the kidney and tumor, without such valuable aids. Cephalography with air injection is a remarkable development and tells much to the cerebral surgeon. The trachea and the lungs have been longer under observation. But now the newer technic can isolate and outline to the most minute detail the size, content and location of a pulmonary cavity, an abscess or a growth. Body section by roentgenography, laminography and tomography solves many problems for the physician and the patient, previously obscure.

The specialist in roentgenology will tell of three methods of body roentgenography:

(1) Focal spot of the tube moves in one direction in a straight line.

(2) Focal spot of the tube crosses circles, squares, or archimedean spirals, but remains in plane of film.

(3) The focal spot of the tube and film rotates about an axis moving in parallel lines.

The study of the spine, the pelvis, with pelvimetry for deformity, and the relative size of the structures and the head of the child tells the obstetrician much about what steps he must take for safe delivery, and the best time.

The human frame has become an open book under the advanced study of every part of the patient's anatomy; the specialists and the family physician each giving his best to place the treatment on a correct basis for cure while it is yet possible. How could such scientific progress result except by the individual and competitive system?

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THE UNIFORM PRODUCTION OF EXPERIMENTAL SHOCK BY CRUSH INJURY: POSSIBLE RELATIONSHIP TO CLINICAL CRUSH SYNDROME

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IN RECENT MONTHS a number of clinical reports[1, 2, 3, 4, 5] have appeared on the condition which results from the compression of extremities by heavy objects for periods of several hours or longer. Most of these accidents have occurred in association with air raids in which persons have been pinned beneath fallen débris. The essential clinical features are these: The patient is usually in fairly good condition at the time of release of the compression; evidences of shock generally develop within a few hours; the immediate response to therapy is usually favorable; and subsequently, after a period of hours or days, the patient develops signs of progressive renal damage. The urinary output diminishes at this time; there is nitrogenous retention; and the urine contains albumin and large orange or brown granular casts. In approximately half of the reported cases death occurred in three to eight days following the compression.

The present study was undertaken in an attempt to reproduce experimentally the so-called crush syndrome. The first efforts consisted in compressing the extremity of the experimental animal by various means, including the use of tourniquets, encircling layers of rubber dam, and pressure between two smooth boards. The results which followed the use of these methods showed considerable variation. It then appeared to be advisable to use objects for compression which did not have a smooth surface and which would exert an uneven pressure, resulting in greater injury to tissues. This method, which will be described in detail, has resulted, in our hands, in the more uniform production of peripheral circulatory failure than we have been able to accomplish by other procedures.

It cannot be stated with certainty that our method has resulted in the causation of the so-called crush syndrome; in fact, it has not been proved conclusively that the crush syndrome as observed in patients is a distinct clinical entity, with features which may not be found following other types of injury. Regardless of whether or not the crush syndrome has been reproduced, the present studies have yielded what appears to be a rather uniform method of causing shock, in which an increase in the concentration of the blood and a fall in blood pressure occur early following the release of the compression.

The present communication presents a description of the method; a report of the effects of compression of one of the posterior extremities of the

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anesthetized animal; and the results of attempts to influence the course of the animals following the release of the compression.

EXPERIMENTAL METHOD

The experiments were performed upon dogs weighing between 7 and 11 Kg. Morphine sulphate in doses of .030 Gm. was given subcutaneously at the beginning of the experiments. Approximately 30 minutes later sodium pentobarbital, .020 Gm. per Kg. of body weight, was given intravenously. One or two subsequent doses of .006 Gm. per Kg. of body weight were usually necessary to maintain anesthesia during the following 18 to 24 hours. The mean arterial blood pressure was determined repeatedly by direct needle puncture of the femoral artery. Hematocrit readings were made with Wintrobe tubes. The bladder was catheterized at the beginning of the experiment and the catheter left in place, so that the character and volume of the urine could be observed at one- to two-hour intervals. Nonprotein nitrogen, plasma creatine, and plasma creatinine levels were determined by the method of Folin and Wu.[6] Blood samples were taken at the beginning of the experiment, immediately before the compression of the limb was released, at one hour, four hours, and six hours subsequently. Creatine and creatinine levels in the urine were determined at corresponding intervals (on individual specimens) by the methods of Folin.[7] All colorimetric determinations were made with an Evelyn photo-electric colorimeter. Urine samples were examined at the beginning of the experiment, and every one to two hours threafter during the experiment, as to volume, gross appearance, presence or absence of albumin, benzidine reaction, hydrogen ion concentration (litmus), and microscopic appearance.

Compression of a limb was produced by an apparatus (Fig. 1) consisting of two three-quarter-inch boards, 15 inches long and seven inches wide, on the inner surface of which were fixed triangular strips of wood measuring 1½x1½x2¼ inches. These strips were placed so that when the boards were approximated their coaptation resulted in a cog or gear-like arrangement. In the center of each strip a groove, one inch in diameter and three-quarters of an inch deep, was made corresponding to the course of the femur. This groove prevented interference with the approximation of the strips and thus ensured the crushing of a larger mass of muscle. Holes, which were three-quarters of an inch in diameter, were drilled in the four corners of the boards. Into these were inserted one-half-inch iron bolts, which were 11 inches long. Threads extended half the length of the shaft and these were fitted with large wing-tipped nuts. Steel compression springs, four inches long, fifteen-sixteenths of an inch in diameter, one-eighth of an inch wire diameter, with 13 effective coils, were placed on the bolts on the upper board. Suitable steel washers were used to protect boards and springs. The springs were calibrated by placing them between the boards and measuring the millimeters of shortening produced by a weight of 500 pounds, which was placed on the upper board.

The dog's thigh was placed in this press and a pressure of 500 pounds was applied for a period of five hours, at the end of which time the press was removed. Approximately half the animals were given no treatment after release of the compression, and observations were made at the intervals de-

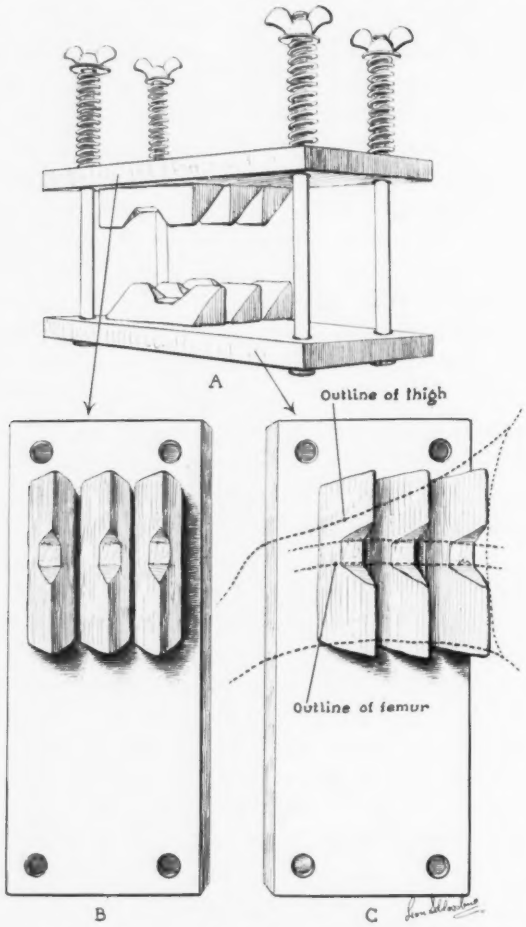

FIG. 1.—Drawings of apparatus used for limb compression. (A) Side view of assembled apparatus with upper board elevated to show relative position of its parts. Pressure is applied to the upper board by tightening the wing-tipped nuts and shortening the springs. (B) Apparatus taken apart to show position of triangular strips of wood and the groove in their centers to fit the approximate course of the femur. These strips are so arranged that their apices fit into the spaces between the strips of the opposite board. In other words, the sharp edges are so placed that they do not touch each other but fit into the corresponding spaces.

scribed above. The other half were treated by the application of a pneumatic rubber cuff (Fig. 2) which was applied to the injured extremity immediately upon release of compression. This cuff consisted of an outer layer of thick rubber which was cylindrical in shape, 17 inches long and five inches in diameter, and an inner layer of thinner rubber which was conical in shape

in order to fit the contour of the extremity snugly. The cuff was fitted with a valve which was connected to the compressed air supply. A mercury column valve was interposed to ensure constant pressure. By means of this cuff a pressure of 40 Mm.Hg. was applied to the extremity for periods of 13 hours in some experiments and 18 hours in others. The loss of fluid into and near the injured area of the animals which died was determined by a bisection method that was described previously.[8]

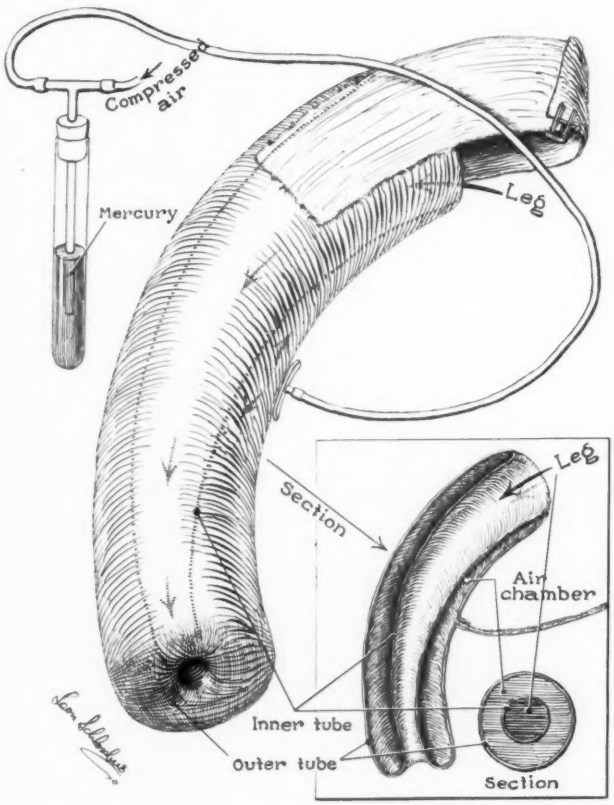

FIG. 2.—Drawing of the pneumatic cuff used in treatment of crushed extremities. The rubber strips at the upper end of the cuff encircle the animal's lower abdomen and are held together by a screw-clamp. Insert—Longitudinal section of the cuff showing air space and conical shape of inner tube which is in contact with the extremity.

RESULTS

The results are summarized in Tables I, II and III. For purposes of description the results of the experiments will be divided into: (1) Crush period, or period of five hours of compression of the extremity; (2) the period following release of compression, no therapy being employed (half of experiments); and (3) the period following release of compression, pressure therapy being used (half of experiments).

TABLE I

THE EFFECTS OF CRUSH INJURIES (UNTREATED GROUP)

Exper. No.	Mean Blood Pressure Mm.Hg.		Pulse Rate per Min.		Hematocrit Reading		Respiratory Rate per Min.		Temperature Degrees F.		Hours Press Applied	Hours Survived After Press Removed	Fluid Loss% Body Weight (Local)
	Control	Reading 2–6 Hrs. After Press Removed	Control	Reading 2–6 Hrs. After Press Removed	Control	Reading 2–6 Hrs. After Press Removed	Control	Reading 2–6 Hrs. After Press Removed	Control	Reading 2–6 Hrs. After Press Removed			
1	130	95	120	172	48.2	71.8	8	12	101.4	102.4	5	6	3.04
2	130	50	68	200	50.2	72.2	10	6	99.6	99.0	5	16 hrs. 15 min.	3.39
3	115	95	56	160	48.3	55.4	6	6	98.9	99.6	5	8	3.02
4	125	75	140	200	44.3	64.7	6	12	98.0	98.0	5	12	3.42
5	125	100	120	200	39.4	43.4	10	16	99.4	102.1	5	Recovered	....
6	125	50	140	200	42.9	67.5	12	6	98.8	98.0	5	7	....
7	115	115	96	108	40.7	58.0	8	8	99.4	99.4	5	12	3.97
8	120	90	84	200	50.4	76.8	10	16	100.0	99.4	5	4 hrs. 35 min.	3.81
9	130	45	120	200	51.3	67.0	8	20	99.0	102.2	5	10	3.40
10	115	75	140	200	56.0	71.1	10	20	99.4	99.0	5	14	3.12
11	125	120	120	160	41.7	72.7	16	16	100.2	98.9	5	6	2.97
12	125	70	120	...	48.4	74.3	6	16	100.1	102.1	5	2 hrs. 20 min.	2.94
13	115	85	120	186	55.0	74.0	10	24	101.2	103.6	5	6	3.46
14	110	75	100	200	56.6	75.8	6	40	100.1	103.1	5	12	3.88
15	130	50	112	200	42.2	72.7	10	40	100.8	103.5	5	2 hrs. 15 min.	3.51
16	120	45	172	200	50.4	76.4	10	40	100.9	103.5	5	5 hrs. 15 min.	3.04
17	130	60	104	180	53.2	78.0	8	40	99.8	102.6	5	5 hrs. 15 min.	3.22
18	125	40	96	172	53.7	72.7	6	10	100.8	102.5	5	11	2.64
19	120	88	140	200	42.7	74.0	6	6	100.6	102.4	5	6	2.67
	Average fall 49.89 Mm.Hg.		Average rise 72.7 per min.		Average rise 44.0% over control values		Average rise 12.00 per min.		Average rise 1.17° F.			Average 7.55 hrs. (excluding survival)	Average 3.26%

TABLE II

THE EFFECTS OF CRUSH INJURIES AND OF COMPRESSION THERAPY

Exper. No.	Mean Blood Pressure Mm.Hg.		Pulse Rate per Min.		Hematocrit Reading		Respiratory Rate per Min.		Temperature Degrees F.		Hours Press Applied	Hours Pneumatic Cuff Applied	Hours Survived After Press Removed*	Fluid Loss% Body Weight (Local)
	Control	Reading 4–6 Hrs. After Press Removed	Control	Reading 4–6 Hrs. After Press Removed	Control	Reading 4–6 Hrs. After Press Removed	Control	Reading 4–6 Hrs. After Press Removed	Control	Reading 4–6 Hrs. After Press Removed				
20	120	115	152	180	40.8	58.8	6	10	100.8	98.2	5	13	Recovered	
21	120	105	132	180	50.2	80.4	12	8	101.2	103.6	5	12	12	3.12
22	130	115	136	192	49.5	69.8	12	16	99.6	104.6	5	13	30	3.14
23	135	110	140	160	52.8	68.4	10	16	98.9	101.4	5	13	30	3.25
24	120	105	96	150	33.4	50.0	6	6	100.6	101.0	5	13	Recovered	
25	125	130	120	116	49.4	51.2	10	8	100.1	98.9	5	13	Recovered	
26	125	105	66	172	42.2	43.3	8	10	103.2	102.4	5	13	Recovered	
27	130	120	160	192	43.7	60.3	10	16	102.4	102.4	5	18	Recovered	
28	130	120	132	180	50.0	66.4	10	12	100.6	99.3	5	18	Recovered	
29	120	120	112	160	46.3	53.6	6	12	101.2	102.4	5	18	30	....
30	125	114	84	160	44.0	54.2	10	10	98.8	98.8	5	18	Recovered	
31	115	140	120	192	47.7	63.0	8	12	99.0	98.2	5	18	Recovered	
32	125	115	120	200	55.8	76.3	16	12	98.4	103.6	5	18	25 hrs. 25 min.	3.29
33	130	115	104	160	43.5	60.3	6	8	99.7	104.4	5	18	Recovered	
34	125	115	120	120	52.3	60.7	6	8	101.2	99.0	5	18	Recovered	
35	126	120	72	72	53.0	67.5	10	8	100.8	99.8	5	18	Recovered	
36	110	110	140	180	52.0	60.0	16	14	101.6	99.8	5	18	Recovered	
37	130	110	110	150	....	....	12	10	101.4	102.3	5	18	Recovered	
38	135	100	112	188	55.2	66.7	10	16	102.2	104.3	5	18	Recovered	
39	132	80	72	160	37.0	44.2	8	8	100.2	102.6	5	18	Recovered	
40											5	7	7	3.50
	Average fall 16.88 Mm.Hg.		Average rise 53.00 per min.		Average rise 28.5% over control values		Average rise 1.88 per min.		Average rise .85° F.				Average survival time 26.33 hrs. (excluding survivals)	Average 3.26%

* The animals listed as recovered were in most instances sacrificed three to four days following removal of the pneumatic cuff. Longer survival periods are being studied at the present time.

TABLE III

BLOOD AND URINARY FINDINGS FOLLOWING EXPERIMENTAL CRUSH INJURIES

Exper. No.	Plasma Creatine* Mg.%		Plasma Creatinine* Mg.%		N. P. N. Mg.%		Urinary Creatine* Mg./Cc.		Urinary Creatinine* Mg./Cc.		Urine Output Cc.		Urine Benzidine Reaction		Urine Albumin	
	Control	Reading 4–6 Hrs. After Press Removed	Control	Reading 4–6 Hrs. After Press Removed	Control	Reading 4–6 Hrs. After Press Removed	Control	Reading 4–6 Hrs. After Press Removed	Control	Reading 4–6 Hrs. After Press Removed	Total While Press on Thigh	Total for 4–6 Hrs. After Press Removed	Control	Reading 4–6 Hrs. After Press Removed	Control	Reading 4–6 Hrs. After Press Removed
1	1.9	2.0	1.5	1.4	25.0	90.0	0.5	5.7	1.4	1.5	46	48	Neg.	Pos.	Neg.	Pos.
2	2.2	3.9	.6	.9	32.5	43.7	1.0	4.5	3.2	1.2	20	45	Neg.	Pos.	Neg.	Pos.
3	1.9	17.4	.9	1.5	32.0	70.5	2.8	1.1	2.2	1.7	67	4	Neg.	Pos.	Trace	Pos.
4	.8	3.6	.9	1.9	30.0	84.0	.5	3.2	2.4	1.7	30	26	Neg.	Pos.	Neg.	Pos.
5	.4	12.8	1.0	3.2	35.2	84.0	.8	6.2	.9	1.6	36	3	Neg.	Pos.	Trace	Pos.
6	1.1	20.1	1.0	1.8	31.0	71.6	.9	.4	2.5	1.5	31	3	Neg.	Pos.	Neg.	Pos.
7	2.3	11.6	.9	2.3	30.0	63.7	1.1	6.7	2.1	.7	39	20	Neg.	Pos.	Neg.	Pos.
8	.4	5.5	1.1	1.5	27.5	81.0	1.0	3.4	2.5	1.1	27	42	Neg.	Pos.	Neg.	Pos.
	Average rise 8.2 mg.%		Average rise .8 mg.%		Average rise 43.2 mg.%		Average rise 2.8 mg.%		Average fall .7		Av. 37 cc.	Av. 23.9 cc.				

* No selection was made as to sex, age or regulation of carbohydrate and protein intake of the animals prior to the experiments. This probably accounts for the high plasma creatine and creatinuria of the control specimens. Control values on 12 animals under the same conditions showed similar results and human specimens showed normal values.

TABLE III—*Continued*

Exper. No.	Urine Reaction (Litmus)		Gross Appearance of Urine		Microscopic Examination of Urine—Catheterized		Blood Pressure		Pulse		Hematocrit		Therapy and Result
	Control	Reading 4–6 Hrs. After Press Removed	Control	Reading 4-6 Hrs. After Press Removed	Control	Reading 4–6 Hrs. After Press Removed	Control	Reading 4–6 Hrs. After Press Removed	Control	Reading 4–6 Hrs. After Press Removed	Control	Reading 4–6 Hrs. After Press Removed	
1	Acid	Alk.	Clear yellow	Grossly bloody	Occasional leukocyte and epithelial cell. No erythrocytes or casts.	Loaded with erythrocytes. Numerous leukocytes and epithelial cells. Numerous red cell casts and granular casts.	130	120	132	180	50.0	66.4	Pneumatic cuff applied. Recovered.
2	Acid	Acid	Clear amber	Grossly bloody	Occasional leukocyte and epithelial cell. No erythrocytes or casts.	Loaded with erythrocytes. Few leukocytes and epithelial cells. No casts.	130	115	160	192	43.7	60.3	Pneumatic cuff applied. Recovered.
3	Acid	Alk.	Clear yellow	Dark brown	Occasional leukocyte. No casts. No erythrocytes. Occasional epithelial cell.	30–40 erythrocytes. Numerous epithelial cells. Few leukocytes.	130	85	112	200+	42.2	67.7	No therapy. Died.
4	Alk.	Acid	Slightly cloudy, yellow	Cloudy, grossly bloody	2–3 epithelial cells. Occasional leukocyte and erythrocyte.	Loaded with erythrocytes. Numerous epithelial cells. 6–8 leukocytes/H.P.F. No casts.	135	100	112	188	55.2	66.7	Pneumatic cuff applied. Recovered.
5	Acid	Alk.	Clear yellow	Grossly bloody	Occasional leukocyte and epithelial cell. No casts or erythrocytes.	Loaded with erythrocytes. 3–4 granular and red cell casts/H.P.F. Numerous epithelial cells and crystals.	120	45	172	200+	50.4	76.4	No therapy. Died.
6	Acid	Alk.	Clear amber	Grossly bloody, brown tinge	Occasional erythrocyte, epithelial cell and leukocyte. No casts.	No casts. Loaded with erythrocytes. Numerous epithelial cells and crystals.	130	60	104	180	53.2	78.0	No therapy. Died.
7	Acid	Acid	Clear yellow	Grossly bloody, brown tinge	Occasional granular cast. Occasional epithelial cell and leukocyte. Occasional erythrocyte.	Loaded with erythrocytes. Numerous red cell casts and large brown granular casts.	125	120	132	180	50.2	73.6	Pneumatic cuff applied. Died.
8	Acid	Alk.	Clear yellow	Grossly bloody, brown tinge	Occasional leukocyte and epithelial cell. No casts or erythrocytes.	Loaded with erythrocytes. Numerous epithelial cells. Occasional granular cast.	120	115	152	180	40.8	55.3	Pneumatic cuff applied. Recovered.
								Average fall 32.5		Average fall 53/min.		Average rise 41.1% over control values	

CRUSH PERIOD

During the crush period there was no significant change in blood pressure in any of the animals. A slight increase in the concentration of the red blood corpuscles was noted in 22 experiments and a slight decrease in 18, the average being an increase of .61 per cent. The pulse rate increased in 30 experiments, decreased in eight and remained unchanged in two, the average being a rise of 20.8 beats per minute. The respiratory rate increased in 23 experiments, decreased in 12 and remained unchanged in five. The average was an increase of 2.3 per minute. The temperature rose in 21 animals and fell in 16, the average being a rise of .36° F. There was an average fall in plasma creatinine of .69 mg.%, and an average increase in plasma creatine of .48 mg.% was observed. Nonprotein nitrogen values increased an average of 4.05 mg.%. Urinary creatine decreased .07 mg. per cc. Urinary creatinine decreased .30 mg. per cc. Microscopic examination showed red blood cells in the urine in every case within two to three hours after the press was applied. The benzidine reaction became positive in two to three hours. Albumin was present in the urine in two to four hours. Except for the urinary findings, it is to be observed that the alterations in most of the functions were minimal.

RELEASE OF CRUSH WITHOUT THERAPY

There were 19 experiments in this group, the results of which are given in Table I. The press was applied to the thigh for a period of five hours. At the end of this time it was removed and the animal was observed, no form of therapy being employed. All animals died except one. Upon removal of the press there was usually a sudden sharp decline in blood pressure to 50 to 60 Mm.Hg. The pressure returned within a few minutes to, or almost to, its former level and subsequently a progressive decline occurred. An increase in the concentration of the red blood cells occurred as soon as the press was removed. This increase was progressive and an average rise of 44 per cent over the control values was observed at the end of periods varying from two to six hours. The pulse rate rose an average of 72.7 per minute. The respirations increased an average of 12 per minute. The rectal temperature increased an average of 1.17° F. The average duration of life in this group was 7.55 hours.

The urine usually became grossly bloody within an hour after the press was removed. The output of urine in this group during the two- to six-hour period following removal of the press averaged 3.3 cc. Although granular and red blood cell casts were frequently found, the dark granular casts, which have been described in clinical cases of crush injury, were not observed.

In three dogs of this group, in which blood chemical and urinary chemical changes were observed, the plasma creatine increased an average of 15.6 mg.% above the control levels. Plasma creatinine levels showed an average increase of 3.45 mg.%, and nonprotein nitrogen an average rise of 44.8 mg.%. Uri-

nary creatine increased an average of 1.03 mg. per cc. Urinary creatinine decreased an average of .25 mg. per cc.

RELEASE OF CRUSH WITH THERAPY

There were 21 experiments in which, following the removal of the press, a pneumatic rubber cuff was applied to the injured thigh at a pressure of 40 Mm.Hg. When the cuff was applied for a period of 13 hours, three of six animals died. When the time of application was increased to 18 hours, three of 15 died. The average survival time of these six animals was 26.3 hours. The average fall in blood pressure of the entire group in the first four- to six-hour period was 16.9 Mm.Hg. Hematocrit volumes increased in this same period an average of 28.5 per cent over the control values. The respiratory rate showed an average increase of 1.88 per minute, and the average elevation of body temperature was .85° F. The pulse rate increased an average of 53 per minute.

Just as in the untreated group, the urine became discolored and showed gross blood within one hour after the press was removed. The average urinary output for the same period of time was 36.2 cc. On microscopic examination of the urine, several animals showed granular and red blood cell casts and an occasional hyaline cast. Two animals of this group showed in the urine large dark brown granular casts which were similar in appearance to those described in clinical cases of crush injury. The urinary creatine output averaged 3.67 mg. per cc. The creatinine output showed an average decrease of 1.27 mg. per cc. Plasma creatine increased an average of 3.60 mg.% and plasma creatinine an average of .57 mg.%.

PATHOLOGIC CHANGES

The pathologic changes in the treated group of animals which ultimately succumbed were, as a rule, more marked than those of the untreated group, probably because the duration of life was longer, and there was a longer period of time in which anoxia could exert its ill effects. There was patchy, bluish discoloration of the lungs, which was most noticeable in the more dependent portions. Microscopically, there was engorgement of the alveolar vessels and extravasation of fluid and cells into the alveolar spaces. The liver showed dark discoloration and the cut surface was moist. On microscopic examination, engorgement of capillaries and degenerative changes in the hepatic cells were noted. The adrenals showed red discoloration on the cut surface, which was most pronounced in the medullary portion, and the vessels were engorged in both cortex and medulla. Degenerative changes were present in the cortical cells, and there was moderate infiltration of polymorphonuclear leukocytes in the zona fasciculata. The gastro-intestinal tract of several animals showed gross hemorrhage; this was greatest in the duodenum and the jejunum. The mucosa of the duodenum and the jejunum was hyperemic, and, on microscopic examination, there was evidence of vascular engorgement. The peritoneal cavity of two animals, and the pleural cavities

of one, contained free fluid. The kidneys were of normal size and on external examination showed no change. The cut surface was darkly discolored in both medulla and cortex. Red radial streaks, indicative of vascular engorgement, were present. Microscopic examination showed engorgement of the glomerular capillaries with extravasation of blood into Bowman's capsules. In some animals homogeneous, amorphous eosinophilic material was present in Bowman's capsules. Vascular engorgement was evident in both cortex and medulla. The collecting tubules in many areas were dilated but empty, and the lining epithelium was flattened. No large brown casts were found.

Examination of the injured extremity revealed massive swelling of the thigh, and to a lesser extent of the leg and foot. There was some swelling of the flank and of the adjacent anterior abdominal wall. Upon section, the swelling was seen to be due to the presence of clear yellow fluid in the subcutaneous tissues, the fascial planes, and the bellies of the muscles. In only two animals which succumbed was there extravasation of whole blood into the tissues of the limb, and in these the amount was very small. The swelling persisted for at least several days. Necrosis and sloughing of the skin were frequently noted at the site at which the maximum pressure had been applied. The pressure resulted in temporary paralysis of the extremity.

DISCUSSION

The type of injury which has resulted in the so-called crush or compression syndrome has, in all reported cases, involved the extremities, and has been of sufficient violence to crush large masses of tissue, especially skeletal muscle. The victims have remained pinned beneath the fallen object for several hours, resulting in great interference with the circulation of the entire extremity and in some instances in the production of necrosis at the site of injury. Following removal of the constricting object, with reestablishment of the blood supply, swelling of the extremity appears. Shortly afterward the patient may present signs of shock and later may develop renal failure. As stated previously, one of the objects of the present experiments was to attempt to reproduce the crush syndrome. When the press described above is applied to an extremity for a period of five hours at a pressure of 500 pounds, the tissues of the thigh are crushed and at least a major portion, if not all, of the blood supply to the part is interrupted for the duration of this period. The popliteal and posterior tibial pulses cannot be felt with the press in place, but are always palpable immediately after its removal. Following the removal of the press there is progressive swelling which seems to reach its maximum in six to eight hours. As can be seen from Table I, shock was produced in all experiments, and was fatal in all animals except one in the untreated group.

The swelling of the extremity is due almost entirely to extravasation of plasma rather than of whole blood. The fluid observed in the tissues of the extremity and the adjacent body wall was a clear yellow; very rarely was there even slight evidence of whole blood loss. At autopsy, the posterior part of the animal's body was bisected and the weights of the injured and uninjured

sides were compared. This comparison revealed a fluid loss in the injured side of 3.26 per cent of the body weight. The results of previous experiments[9] of approximately the same duration in which plasma was removed from the blood stream indicate that the local loss in the present experiments was the major factor in causing the decline in blood pressure and death. Probable explanation for the plasma loss lies in the local mechanical injury to tissues plus the anoxia produced by the constricting or tourniquet effect of the press.

Further evidence of plasma loss is demonstrated by the marked increase in the concentration of the red blood corpuscles which invariably occurred. This rise began immediately after the press was removed and progressed in the untreated group until the animal died. The average rise in the untreated group was 44 per cent above the control values as compared with 28.5 per cent above the control values in the treated group.

In the animals which were successfully treated by application of the pneumatic cuff there was comparatively little swelling of the injured extremity at the time of removal of the cuff after 13 or 18 hours. Swelling became more evident within a few hours and appeared to become greater in those treated for 13 hours than in those to which the cuff was applied for 18 hours. In animals which died in spite of treatment, comparison of the weight of the injured and uninjured sides showed a fluid loss as great as that of the untreated group (3.26 per cent of body weight). The beneficial effect of the pneumatic cuff would appear to be due chiefly to its rôle in lessening local fluid loss into the extremity. It is likely that a partial repair of the increased capillary permeability in the injured extremity takes place following the return of its blood supply during the 18 hours that the pneumatic cuff is in position.

The urinary changes in these experiments are of interest. Blood was present, on microscopic examination of the urine, within two to three hours after the press was applied. The development of hematuria probably precedes an appreciable diminution in blood volume and blood pressure, and also probably precedes the absorption into the general circulation of the major part of the products of injury. There may be some absorption of these metabolic products at the upper end of the press and through collateral channels where the circulation is still intact. Gross blood was present in the urine within an hour after the press was removed. A peculiar brownish discoloration of the urine was often noted during the period following removal of the press. Oliguria was observed in all experiments, most severe in the untreated animals and in those which died in spite of treatment, that is to say, those animals in which shock was most profound. This oliguria was due at least in part to the physiologic imbalances accompanying shock—diminished blood volume and flow, depression of blood pressure, and hemoconcentration. Granular and red blood cell casts were frequently found and occasionally hyaline casts were noted, but in no animals of the untreated group, and in only two of the treated group, were large, brown granular casts observed. In these two animals, histologic examination did not show the selective tubular changes and the casts which have been described in clinical cases of crush injury. Had the

length of life been greater, it is possible that this observation would have been made more often.

Elevated blood creatine levels and creatinuria have been observed in several types of muscular disease.[10] Aub and Wu[11] have reported an increase in blood creatine following injuries to muscle. The values we have obtained are high, and are suggestive of severe muscle damage. Marked disturbance of creatine-creatinine ratios in blood and urine were observed. The levels are higher in the plasma of the untreated group than in that of the treated group, and higher in the urine of the treated group than in that of the untreated group. These observations may indicate failure of excretion of the excessive creatine because of diminished renal function. Destruction of renal function in itself will produce an elevation in blood creatine.[12, 13] Further evidence of diminished renal function and tissue injury is presented by the progressive rise in nonprotein nitrogen seen in all the experiments.

The method which has been described presents both advantages and disadvantages in the study of shock. Included among the advantages is the observation that there appears to be less individual variation in the responses of animals to this form of injury than to any other that we have studied. This method allows one to study, with greater exactness, the pathogenesis of shock, and to determine, with greater certainty, the effects of various therapeutic procedures. Another advantage which is common to all methods in which one extremity is injured is that the opposite extremity can be used as a control. A disadvantage of the method is that the type of injury which is produced is not encountered as frequently in patients as are burns and some other types of trauma.

It remains to be proved whether or not the crush syndrome as observed in patients can be reproduced by this method. The alterations in the urinary tract in the experimental animals and in the patients are not identical. Most of the animals which survived following treatment with the pneumatic cuff were sacrificed after several days, hence a study of the late effects of injury is incomplete. Such studies are being carried on at the present time. It will probably be necessary to modify the method in such manner that the survival period of untreated animals will be lengthened. It is apparent that a careful study of renal function in this experimental condition is indicated.

SUMMARY

A new method for producing shock, in which an attempt is made to simulate the crush syndrome as observed in patients, is described. The method consists in placing a posterior extremity of the anesthetized animal in an apparatus with uneven surfaces, which exert great pressure on the soft tissues.* Removal of the extremity from the press is followed by swelling of the leg, an increase

* It is to be emphasized that medium sized animals which had a good deal of muscular tissue in the thigh were chosen and that the grooves in the insets of wood on the press allowed the pressure to be made mainly on the soft tissues rather than on the femur.

in the concentration of the blood, a decline in blood pressure, oliguria, abnormal urinary findings, elevated blood creatine and creatinuria, and usually death. The local loss of plasma is great. Recovery usually results if, at the time the press is removed, the injured part is placed immediately in a pneumatic tube with an internal pressure of 40 Mm.Hg.

Whether the experimental conditions have any relationship to the crush syndrome as observed in patients remains to be proved, but it can be stated that the use of this method results in a more uniform production of traumatic shock than any with which we have hitherto worked.

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FURTHER OBSERVATIONS ON STAB WOUNDS OF THE HEART

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I SHOULD like to report upon three points concerning the subject of penetrating wounds of the heart. Noteworthy achievement in the repair of these wounds has been accomplished by Elkin,[1] of Atlanta, Bigger,[2] of Richmond, and Griswold,[3] of Louisville. Contributions to the subject have been made also by numerous other surgeons. The writer has had little or no experience with patients who were brought to the operating room because of a stab wound of the heart. He has accidentally made wounds of the heart while carrying out other operations upon this organ in the human, and these wounds have had to be repaired. He has had considerable experience with the heart in the experimental laboratory. Whether the wound is in the human heart or in the heart of a dog, the methods of handling it are the same. Because of this, I feel that I can make a few additions to the subject.

The best way to stop bleeding from a ventricle is by placing a finger *upon* and not *in* the wound. It is difficult, or impossible, to keep the finger on the wound because of the movement. It slides off and there is a squirt of blood. However, it can be kept on the wound fairly well, if the heart is steadied by a suture. This can be done by placing a suture in the apex of the heart and holding this suture between the thumb and third finger of the left hand while the index finger of that hand is placed upon the wound. In this way the hand moves with the heart and you do not get so many squirts of blood. The apex was selected for this suture because this region is farthest from the major coronary arteries, and there is least likelihood of inflicting injury to one of these important arteries in this location. Often the surgeon wants to place this suture without delay because of bleeding. To inspect the heart in order to find a place for the suture takes time. The apex is always a favorable place for it. These points originated, I believe, from experiments upon dogs.[4] Griswold describes this "hot-spot" in the operation as follows: "There is nothing more disconcerting than to hold in one's hand a writhing, jumping heart and blindly attempt to find a wound deep in a gushing whirlpool of blood. The insertion of a traction suture converts this stage of the operation from futile blundering into an orderly process. The traction suture steadies the jumping organ so that a finger may be placed over the opening to temporarily staunch the flow."

The next step consists of closure of the wound. According to the original method, a traction-suture was placed on each side of the finger, crossed, and held under gentle traction by the assistant. The finger was then taken off the wound. These traction-sutures were supposed to stop the bleeding, and the wound was then closed by permanent sutures. Elkin modified the method by placing a temporary suture under the finger and across the wound. Traction on this suture stopped the bleeding. Bigger and Griswold have used

Elkin's modification of this technic to good advantage, and it seems to be the method of choice. If the wound lies along a coronary artery, the method should be such that the artery is spared. The original method spared this artery. The traction-suture on each side of the finger was placed under vision so that these sutures would not get the artery. The wound was sutured under vision so that the artery could be spared in these sutures. Interrupted sutures were used in the illustration of the method. A mattress suture was not illustrated. An illustration of a mattress suture for closure of a wound close to an artery is shown in Figure 1. Griswold also recommends a mattress suture for wounds adjacent to an artery.

FIG. 1.—Method for repair of wound situated adjacent to coronary artery. The wound can be closed by one or more mattress sutures without sacrificing the coronary artery.

The type of wound to which I refer is illustrated in Figure 2, taken from a paper by Olim and Hughes.[5] A quotation from this article follows: "There was a laceration 1.5 cm. in length on the anterior surface of the left ventricle, approximately 2 Mm. to the left of the left anterior descending coronary vessels and about 5 cm. from the apex (Fig. 2). The laceration penetrated the chamber of the left ventricle, and as soon as the tamponade was released, great streams of blood spurted. A silk traction-suture was placed in the apex, as described by Beck, in order to steady the heart. An attempt was made to close the laceration with silk sutures and to avoid the coronary vessels, but due to the narrow band of myocardium between the laceration and the vessels, this was found to be impossible, as the sutures pulled through the frayed muscle on two attempts. Because of the critical condition of the patient and the excessive blood loss taking place, it was thought unwise to

make further efforts at preserving the coronary vessels. Four interrupted silk sutures were then placed so that the vessels were encircled and the laceration closed." Electrocardiographic evidence of a myocardial infarct developed. The patient recovered.

Davenport, Blumenthal, and Cantril[6] reported a patient who had a stab wound of the heart: "The puncture which caused the bleeding into the pericardial sac was found at the apex of the left ventricle and corresponded in size to the point of an ice-pick. It was situated one millimeter from the coronary artery and vein. The wound in the heart wall was not spurting blood, but it was considered advisable to suture the wound to prevent subsequent hemorrhage. Three sutures of black silk were placed in the heart with a curved needle. The first suture was left long as a guide. The other two were placed around the wound including the left descending coronary artery and vein, one above and one below." Electrocardiographic evidence of infarction in the anterior wall of the heart was obtained after operation. The patient recovered.

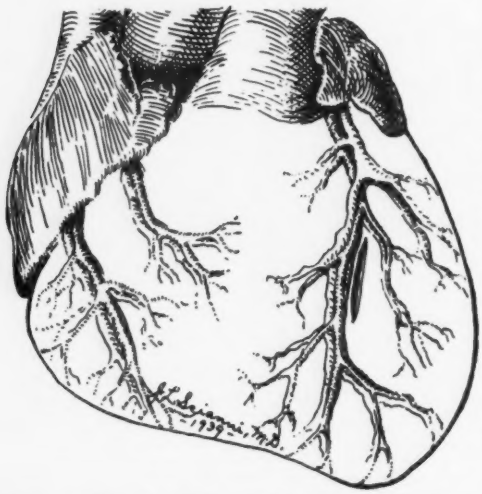


FIG. 2.—Wound of left ventricle situated adjacent to descending ramus of left coronary artery. Coronary artery and vein were sacrificed by the sutures. (Olim and Hughes, Jour. Thoracic Surg., 9, 99, 1939.)

Badertscher[7] reported a patient who was stabbed in the heart: "On incising the pericardium from base to apex, the hemorrhagic tamponade was released and the heart resumed rapid activity, resulting in a terrific hemorrhage. The laceration in the heart was 6 Mm. long, and had perforated the right ventricle immediately adjacent to, and parallel to, the right border of the descending ramus of the left coronary artery in its proximal third. Hemorrhage was controlled by silk sutures deep in the ventricular wall, parallel to the laceration on either side. Free ends of the sutures were twisted to form a single strand on each side of the wound and then tied over the wound as a single suture. Several such sutures were required to control the hemorrhage. Although the coronary artery was not encircled by the sutures, it must have been occluded by the inverting effect. On control of hemorrhage from the heart, the blood pressure immediately rose to 120/80 and became stable. The heart, observed for 15 minutes, became progressively cyanotic, most markedly at the apex. The chest wall was closed in layers. As the skin sutures were being applied, the blood pressure suddenly disappeared. This was approximately 25 minutes after occlusion of the coronary artery. In retrospect, we feel that it is possible that this patient's life might have been saved had deep sutures been used to close the heart wound, thus leaving the coronary vessels unobstructed on the surface of the

heart. Some of these important technicalities, unfortunately, are overlooked when one is working under pressure, and on such an elusive object as a rapidly beating heart."

I can appreciate Badertscher's feeling in this regard. I recall, as though it were yesterday, an experience that I had in 1931. I tore a hole in the right auricle in the region where the superior vena cava joins the auricle. I was dissecting a tuberculous scar from the auricle when this occurred. I

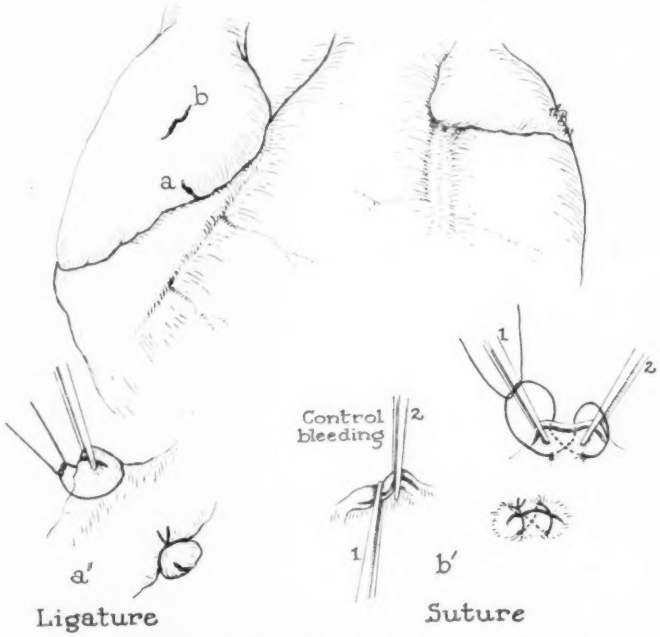


FIG. 3.—Methods for the repair of auricular wounds: Auricular wall can be taken in a hemostat without crushing it. A wound along the margin of the auricle can be repaired by a ligature as in (a). A wound elsewhere, as in (b), is repaired by picking up the edges of the wound in hemostats and bringing the points close together to stop bleeding. Sutures are then placed for closure.

followed my first impulse and placed a finger upon the tear. It was utterly ineffective. Blood poured out from beneath my finger and I could not see the wound. After losing about 500 cc. of blood, or more, the wound was exposed and the margins of the wound were taken in clamps and easily sutured. It was not a difficult tear to suture after it was taken in hemostats but the situation of placing a finger upon the wound was very bad indeed. In our laboratory we often tear an auricle in dissection of coronary arteries. As a rule, it is an easy problem to handle. The margin of the wound is picked up in a small hemostat and the wound is either closed by suture or by mass-ligature. The ligature is good if the wound is at the margin of the auricle (Fig. 3). The use of clamps for the repair of auricular wounds was described by me in 1934,[8] and by Elkin,[1] in 1941.

I have often stopped bleeding from the surface of the heart by placing a superficial suture in the muscle at the bleeding point and tying a small muscle graft into the suture. A small muscle graft can stop bleeding from a coronary

vein. It can be loosely anchored over coronary vein and coronary artery in such a way that the vein does not bleed and the artery is not occluded.[9] Bigger[10] sutured the pericardium into a wound for closure. In his case the

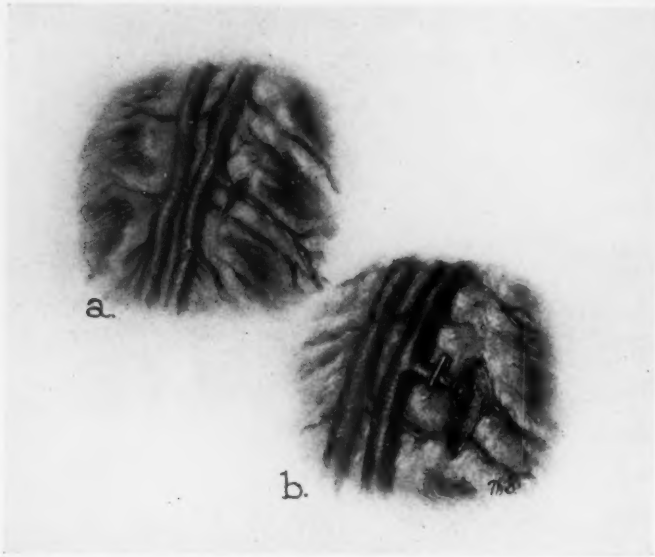


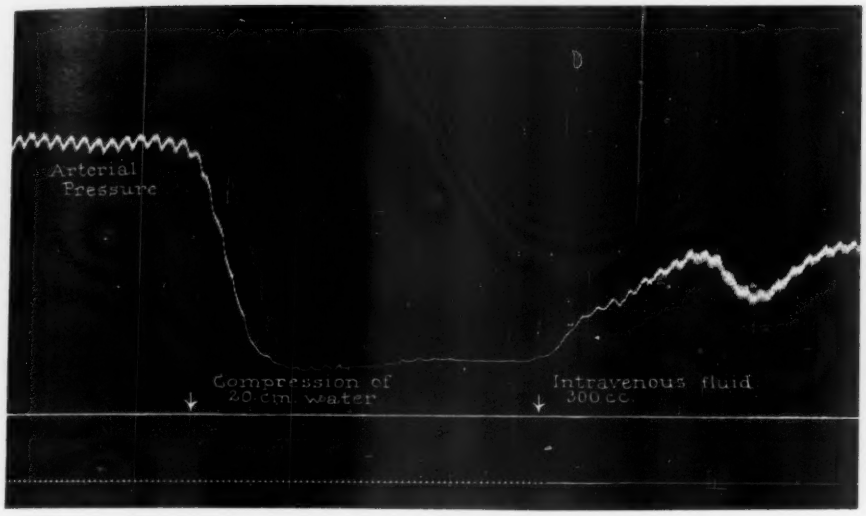
FIG. 4.—(a) Branch of major coronary artery severed close to its origin. (b) Magnification of same. This artery occluded by brain clip without injury to main artery.

muscle was very soft and friable and sutures had a tendency to tear out. Cushing's brain clip is sometimes useful. (Fig. 4.) Perhaps Bigger[11] might have found a clip useful in one of his cases. In his case "the injury was so close to the main stem of the artery that it was felt that if an attempt was made to ligate the injured vessel which had stopped bleeding, it would in all probability be necessary to ligate the main artery. It was decided, therefore, that it would be better to close the operative incision and take the chance of having to reopen it if bleeding and tamponade occurred." The patient recovered.

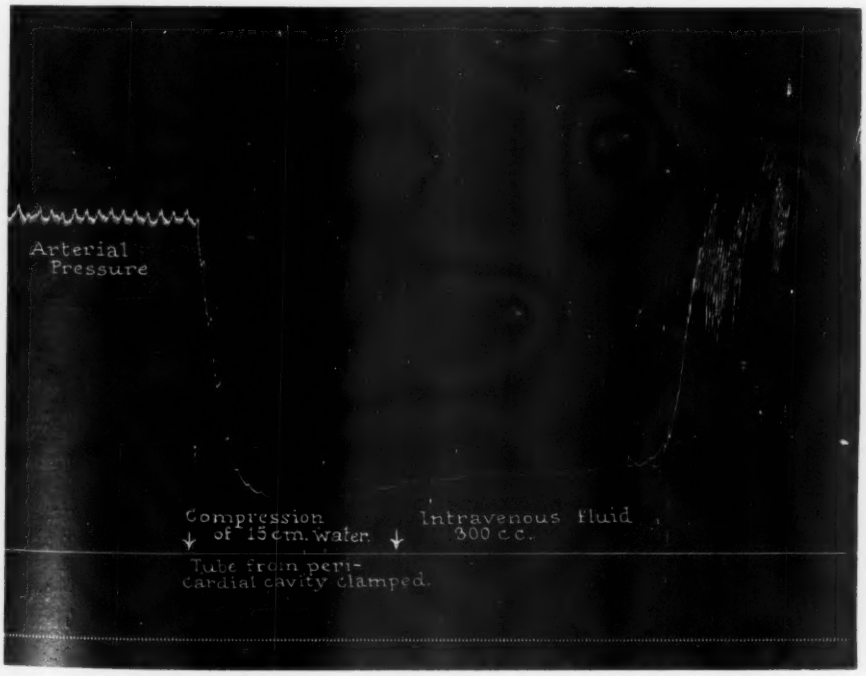
In 1933, Bigger and Wilkinson[12] described a method which they employed satisfactorily for the repair of a stab wound of the superior vena cava. A finger was placed under the vena cava and the vein was elevated. This collapsed the vein and stopped the bleeding. The wound was successfully sutured.

The other point that I should like to discuss concerns the administration of fluid intravenously in patients with acute compression of the heart. Bigger advocates the administration of blood, acacia solution, glucose or sodium chloride solution as a preoperative measure in patients who have received a stab wound of the heart. Griswold states that intravenous fluids, particularly blood, should be administered when hemorrhage has occurred but are of little value preoperatively in case of tamponade.

Two types of experiment are interesting in this connection. In one type (Graph 1) the heart is compressed by a force of 20 cm. of water. The arterial pressure falls and remains low. This compression force is kept on the heart at 20 cm. and 300 cc. of fluid is given intravenously. The arterial



GRAPH 1.—Experiment: Arterial pressure was recorded. Cannula attached to parietal pericardium and 20 cm. of pressure applied to heart. Fluid was given intravenously while the pressure was maintained at 20 cm. Some fluid was allowed to escape from the pericardial cavity in order to keep the pressure on the heart at this level. The administration of fluid intravenously produces a rise in arterial pressure under these conditions.



GRAPH 2.—Experiment: Arterial pressure was recorded. Cannula attached to parietal pericardium and 15 cm. of pressure applied to heart. After this pressure was established, a clamp was placed upon the tube so that none of the fluid could escape from the pericardial cavity. Fluid was then given intravenously. The arterial pressure did not rise.

pressure rises when the fluid is given. In the other type of experiment (Graph 2) the heart is compressed by a force of 15 cm. of water. A clamp is placed on the tube leading to the pericardial cavity so that fluid cannot escape from the pericardial cavity. The quantity of fluid in the pericardial cavity is fixed. The arterial pressure falls and remains low. Fluid, 300 cc., is given intravenously. The arterial pressure does not rise.

It appears, then, on the basis of such experiments, that the administration of fluid intravenously produces a rise in arterial pressure if the degree of compression on the heart is fixed and does not rise to higher levels, as the venous pressure rises when fluid is given intravenously. For this to occur some of the fluid must escape from the pericardial cavity. If the quantity of fluid in the pericardial cavity is fixed and none of it can escape then the administration of fluid intravenously does not result in a rise in arterial pressure. As the venous pressure goes up, the degree of compression also goes up.

The one experiment applies to the patient with compression in whom some blood is escaping from the pericardial cavity. The administration of fluid intravenously has a beneficial effect in this patient. The other experiment applies to the patient with compression in whom there is no blood escaping from the pericardial cavity. The wound in the pericardium has become sealed. The administration of fluid intravenously does not produce a rise in arterial pressure in this patient.

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DIAPHRAGMATIC HERNIA OF CHILDREN*

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DIAPHRAGMATIC HERNIA occurring in infants and children presents many problems of diagnosis and treatment that differ markedly from those caused by such herniae occurring among adults. One of the principal reasons for this variation is the difference in the types of diaphragmatic hernia which are most commonly encountered in these periods of life.

Although any of the various types of diaphragmatic hernia may be encountered in any period of life, the more common types seen among infants and children, in order of frequency, are those due to embryologic structural defects of the diaphragm, namely, pleuroperitoneal hiatus herniae and those caused by congenital absence of the diaphragm. Next in probable order of frequency are esophageal hiatus and traumatic herniae.

TABLE I

DIAPHRAGMATIC HERNIA

SITE OF OPENING AND CONTENTS OF HERNIA IN 304 ADULTS AND CHILDREN

Site of Opening	Adults	Children	Contents of Hernia	No. of Cases
Esophageal hiatus	222	5	Stomach (omentum)	215
			Stomach, omentum and spleen	4
			Stomach and colon	8
Esophageal hiatus with short esophagus	15	0	Stomach only	15
Hiatus pleuroperitonealis	2	6	Right colon and small bowel	4
			Colon, small bowel, stomach and spleen	4
Absent posterior fourth of left diaphragm	1	6	Stomach, colon, small bowel and spleen	4
			Colon and small bowel	2
			Colon, appendix, small bowel and spleen	1
Foramen of Morgagni (subcostosternal)	5	0	Omentum only (2) and fat (1)	3
			Colon and omentum	1
			Omentum, cecum, appendix, colon and terminal ileum	1
Left hemidiaphragm	37	4	Stomach only	5
			Stomach and colon	10
			Stomach, colon, small bowel (24), spleen (15) and liver (8)	26
Right hemidiaphragm	1	0	Stomach, duodenum, colon, small bowel, liver (gallbladder) and head of pancreas	1
Total	283	21		304

In adult life the most common type of diaphragmatic hernia encountered is that which occurs through the esophageal hiatus. Although this type of hernia may be considered congenital in origin, the actual herniation often does

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not occur until late in life. Other types of diaphragmatic hernia occurring among adults, listed in the probable order of frequency, are traumatic herniae, subcostosternal (foramen of Morgagni) herniae, and those resulting from structural deficiencies of the pleuroperitoneal membrane.

In a series of 304 cases of diaphragmatic hernia in which operation was performed at the Mayo Clinic, 283 of the patients were adults and 21 were children 12 years of age or less. The relative frequency of the occurrence of the various types of hernia among adults and children and the abdominal viscera involved in the hernia in this series are shown in Table I.

The reason for the relative infrequency of those herniae that occur through structural defects of the diaphragm among adults is that most of the infants who are born with this type of hernia die in the first few hours or days of life of cardiac or respiratory difficulty resulting from the marked unilateral alteration in intrathoracic pressure at a time when the compensatory respiratory and cardiac reserve has not been developed to a sufficient degree to maintain function. However, if the respiratory and cardiac mechanisms are able to compensate for the presence of the abdominal viscera in the thorax, the patients may reach childhood or even adult life without any great amount of disability or symptoms, provided that intestinal or gastric obstruction does not develop. When the stomach is involved in these herniae, it usually becomes markedly dilated and the patients often have symptoms of partial gastric obstruction. Intestinal obstruction may occur owing to bands of adhesions between the omentum and loops of bowel, owing to inflammatory conditions of the bowel, or owing to appendicitis.

The clinical recognition of diaphragmatic hernia on the basis of subjective symptoms alone is often difficult. The symptoms are complex because of the various structures involved in the hernia. They depend on the amount of mechanical interference with the function of the herniated abdominal viscera, on the degree of the impairment of the normal function of the diaphragm, and on the amount of increased pressure within the thorax causing impairment of respiration and circulation.

The urgency of establishing a diagnosis is not as great in the case of adults as it is in the case of infants. In the latter case it is extremely important to establish a diagnosis as soon as possible. Many of these infants are born with a rapid, feeble pulse, are cyanotic, and are often considered to have cardiac disease. When infants present symptoms of cardiac or respiratory difficulty the thorax should be examined immediately; if possible, a roentgenogram should be made, and if a hernia is present, treatment should be instituted immediately.

The pleuroperitoneal hiatus types of hernia and herniae due to congenital absence of the diaphragm, which are the most common types of diaphragmatic herniae seen among infants and children, may be considered under one general heading as both of these types of hernia are caused by deficiencies of the development of the pleuroperitoneal membrane, which forms the posterolateral portion of the adult diaphragm.

The former (the pleuroperitoneal hiatus hernia) is due to a lack of fusion of the pleuroperitoneal membrane with the septum transversum, which results in a congenital continuity between the peritoneal and thoracic cavities. The opening is in the posterolateral portion of the diaphragm but varies with the amount of deficiency which has occurred in the formation of the pleuroperitoneal membrane. The opening is usually triangular or elliptic in shape and may be entirely within the diaphragmatic muscle posterolaterally, or there may be no diaphragm posteriorly with a triangular shaped opening reaching to the thoracic wall laterally with its apex toward the central tendon. In this type of hernia the abdominal viscera which usually are involved are the cecum (appendix), ascending colon, greater portion of the transverse colon and practically all of the small intestine. In the larger herniae which present posteriorly, the spleen may be involved. The stomach is usually in the abdomen. It may be markedly dilated and at times extend into the pelvis.

In the second type of congenital hernia, which is due to absence of the posterior portion of the diaphragm, there is a much larger deficiency caused by lack of formation of that portion of the diaphragm derived from the pleuroperitoneal membrane and probably the wolffian body. There are various gradations of the amount of the defect so that the size of the opening varies with the amount of the deficiency of the formation of the diaphragm. It usually amounts to approximately a fourth of the hemidiaphragm posteriorly, from the angle of the ribs laterally to the median portion of the diaphragm close to but not involving the esophageal hiatus. In this type of hernia the same abdominal viscera are involved as in the pleuroperitoneal hiatus types of hernia. The viscera involved are the ascending and transverse colon, small intestine and spleen, and, in addition, usually the stomach and occasionally the left lobe of the liver. The left kidney is usually elevated to a position above the level of the diaphragm in this type of hernia, while in the pleuroperitoneal hiatus type of hernia it is below the level of the diaphragm.

It is difficult to differentiate these two types of hernia clinically because the roentgenologic examination is often misleading in cases in which hernia results from congenital absence of the posterior portion of the diaphragm, as in many instances, at the time of the roentgenologic examination, the stomach is found to be in the abdomen and, at the time of the operation, it is found to be herniated into the left thoracic cavity. This I believe is due to the weight of the barium which causes the stomach to drop into the abdomen where it undoubtedly is a great deal of the time during life. It doubtless goes back and forth through the large opening posteriorly because the opening extends up to the esophageal hiatus. Because of the roentgenologic finding of the stomach in the abdomen, this type of hernia may be thought to be a true pleuroperitoneal hiatus type of hernia rather than due to a congenital absence of a larger portion of the diaphragm.

These herniae rarely have a hernial sac, and the abdominal viscera are in direct contact with the thoracic viscera. There is usually a failure of rotation of the colon and occasionally the small bowel is enveloped in a congenital

peritoneal fold which constitutes an internal hernia. In many instances there is a congenital malformation of the mesentery of both large and small intestines. This is very important surgically and great care must be exercised in replacing the intestines into the abdomen because of the danger of twisting the mesentery upon itself and obstructing the blood supply to the intestine. The herniated viscera produce marked or complete collapse of the left lung and often cause a marked shift of the mediastinum to the right. This shifting of the mediastinum depends on the amount of distention of the herniated abdominal viscera.

As I have stated previously, although the esophageal hiatus type of hernia may be considered to be essentially of congenital origin owing to defective formation of the esophageal hiatus, it usually does not occur until later in life. This type of hernia, however, may be of congenital origin and occur at birth, but the congenital occurrence of this type of hernia is relatively infrequent as compared to those herniae resulting from structural deficiencies of the diaphragm.

There are several types of esophageal hiatus herniae caused by the situation of the muscular defect of the hiatus. The most common site of the defect in the case of children is posterior. This type of hernia may be thought to occur through the aortic opening, but there is usually a small membranous portion of the defective hiatus in front of the aorta and the hernia does not occur through the anatomic aortic opening, which, in reality, is situated back of the diaphragm. The muscular defect of the hiatus in adult life is more commonly situated to the left of the esophagus and permits the stomach to extend into the posterior mediastinum and left side of the thoracic cavity. Occasionally, the muscular defect in the hiatus is situated posteriorly. In this instance, the herniated viscera extend into the right side of the thoracic cavity.

I believe that the occurrence of these esophageal hiatus herniae, both the congenital and acquired types, has a definite relationship to the embryologic formation of the posteromedian portion of the diaphragm as well as to the embryologic relationship of the descent of the stomach and the transverse septum. The transverse septum with the pleuroperitoneal membrane begins to migrate caudally in the 7-Mm. embryo and rapidly passes the pulmonary buds and the anlage of the stomach, placing the greater portion of the lung in the pleural cavity and the anlage of the stomach partially above the diaphragm.

In the 11-Mm. embryo, the stomach, which has been practically stationary, follows rapidly behind the descending septum transversum, and in the 17-Mm. embryo it has virtually reached its permanent position. This descent is made possible by the sudden elongation of the esophagus. During this descent the right and left dorsopleural recesses are converted into bursae which surround the cardia. The left bursa usually disappears, and the right bursa, when well developed, is known as the "infracardiac bursa" and bears a definite relationship to congenital esophageal hernia.

Inasmuch as the stomach descends behind the septum transversum, if

there is a delay in descent of the stomach, the lumbar portion of the diaphragm will be imperfectly developed and the esophageal hiatus will be formed around the cardiac end of the stomach instead of around the esophagus. This will result in an abnormally large hiatus with deficiency both in the muscle ring and in the attachments of the diaphragmatico-esopageal membrane. The degree of the deficiency depends on the amount of gastric anlage in the thorax at the time of muscularization of the lumbar portion of the diaphragm. In rare instances, the stomach may remain in the elevated position as a result of a congenitally short esophagus and a partial thoracic stomach will result. In most instances, the esophagus continues to elongate normally, thus placing the stomach below the diaphragm. This abnormal position of the stomach will cause an abnormal enlargement of the esophageal hiatus with a wide space between the margin of the muscle and the wall of the esophagus. It will also result in imperfect fixation of the diaphragmatico-esophageal elastic tissue membrane to the esophagus and stomach and in an abnormally large peritoneal fold extending well down on the cardia of the stomach. This abnormal relationship will permit much more flexibility of the esophagus in the enlarged hiatus than is normal. The more defective the formation of the hiatus, the more likely is herniation of the stomach to occur through it in later life. The true congenital hernia, present at birth, may be explained in the same way, but it is probable that persistence of the dorsopleural recess may be a factor in the origin of congenital esophageal hiatus hernias.

In the series of 304 cases which I have operated upon, the relative incidence of traumatic hernia was slightly higher among children (19 per cent) than it was among adults (13.4 per cent). Traumatic diaphragmatic hernia may be caused by direct or indirect injury, or by inflammatory necrosis of the diaphragm. In cases of indirect injury of the diaphragm, the hernia may occur at any point, including points of embryologic fusion, but the most common sites are the dome and posterior half of the left part of the diaphragm. However, the injury may occur in the right part of the diaphragm. The laceration most commonly occurs in the posterior third of the left hemidiaphragm; it may be entirely within the suspended portion of the diaphragm, extending to but rarely involving the esophageal hiatus. It may extend to the thoracic wall and the diaphragm may be partially torn from its attachment to the thoracic wall. In case of direct injury of the diaphragm, the hernia may occur at any point and is usually the result of penetrating wounds, such as gunshot and stab wounds.

These traumatic herniae do not have a hernial sac, and the abdominal viscera are in direct contact with the thoracic viscera. The condition in these cases may be more properly termed "evisceration of the abdominal organs into the pleural cavity" rather than a "true hernia." The most common abdominal viscera involved in the hernia are the stomach, colon, small intestine, spleen, and occasionally the liver.

The most marked immediate symptoms usually are respiratory and circulatory embarrassment. The sudden onset of symptoms in cases of traumatic

hernia usually is directly attributable to the injury and there is rarely a question as to the clinical diagnosis. Surgical treatment is demanded because of the danger of cardiac and respiratory failure or because of intestinal strangulation.

SURGICAL TREATMENT

The urgency of and the indications for surgical treatment in the case of infants and children differ from those in the case of adults because of the more frequent occurrence of herniae caused by structural deficiencies of the diaphragm among infants and children. This type of hernia demands immediate surgical intervention because the longer the interval between birth and operation the greater the technical difficulties and the greater may be the hazard of operation. If operation is delayed for a long period, the abdominal viscera will have lost their right of residence in the abdomen, in that the abdominal cavity will not have developed sufficiently to contain them and there will be marked increase in the intra-abdominal pressure when the viscera are placed in the abdomen. At birth, the defect is relatively smaller in proportion to the size of the thorax than it is later in life. In the case of infants who live, the thoracic wall grows away from the posterior margin of the defective diaphragm because there is no posterior attachment. The opening which must be closed, therefore, becomes much larger as the child becomes older. Even though the diaphragmatic muscle is relaxed by interruption of the phrenic nerve, there may not be sufficient diaphragm to span this opening. In cases in which the hernia is due to congenital absence of the posterior portion of the diaphragm, the defect is often proximal to the left kidney and the pararenal fascia can often be utilized in completing and securing the closure after interruption of the phrenic nerve.

One of the chief dangers associated with the repair of these herniae is marked alteration of intrathoracic or intra-abdominal pressure. It is very important in these cases that the respiratory function be maintained by positive pressure during the operation and that at the completion of the operation a negative pressure be obtained and secured in the thoracic cavity. A roentgenogram should be made at the completion of the operation to insure that there is no shifting of the mediastinum owing to the pneumothorax. I do not permit the patient to leave the operating table until I have seen the roentgenogram. If there is any shifting of the mediastinum, more air is withdrawn to maintain the mediastinum in the midline.

I believe it is advisable to effect a temporary interruption of the phrenic nerve preliminary to repair of these herniae, as in some instances it may not be necessary for the resultant paralysis to be permanent. A piece of black silk is looped around the nerve and anchored to the posterior border of the sternomastoid muscle for future localization of the nerve if it is thought necessary to make the paralysis permanent. I do not think it is ever advisable to paralyze the diaphragm of an infant permanently unless it is essential to repair of the hernia, as such paralysis may lead to an eventration of the

diaphragm which may be associated with gastric and intestinal symptoms later in life. A temporary interruption of the phrenic nerve will paralyze the diaphragm for three to six months and, in the case of infants, I prefer to do this immediately preceding the abdominal repair of the hernia which is done under general anesthesia.

I prefer ether as the anesthetic agent for infants and cyclopropane for adults. In all herniae in which there is a direct continuity between the abdominal and pleural cavities I prefer intratracheal administration of the anesthetic agent by means of a positive pressure machine.

In the treatment of all herniae that have occurred through the left portion of the diaphragm, I prefer the abdominal approach by means of an oblique left rectus incision, starting at the ensiform cartilage and extending to the outer border of the rectus muscle. I believe there is less risk of the occurrence of thoracic complications when this approach is used. It is of particular advantage in cases of esophageal hernia as the herniated stomach is usually confined in a sac in the posterior part of the mediastinum and does not enter the true pleural cavity. Inasmuch as these abdominal viscera have herniated into the thorax, their true relationship can be more readily determined by following their course from the abdominal side, and if an injury to the stomach or other abdominal viscera occurs during the operation, it can be readily recognized and immediately repaired.

In the repair of herniae through the right portion of the diaphragm, I prefer the thoracic approach, because the large, right lobe of the liver makes the abnormal opening in the diaphragm inaccessible from the abdominal approach.

The technical difficulties of adequate exposure of the hernial openings through the left portion of the diaphragm and the esophageal hiatus are often considerable because of fixation of the left lobe of the liver to the leaf of the diaphragm. The exposure of these hernial openings is greatly facilitated by cutting the suspensory ligament and retracting the left lobe of the liver to the right. This can be accomplished, when the left lobe is small, by folding it on itself, and when it is large, by retracting it forward into the wound. The spleen is often very adherent to the posterior part of the diaphragm and hernial openings, but usually can be separated from these structures by blunt dissection. In some instances the spleen has been so injured and so firmly fixed in its abnormal position by adhesions that it cannot be separated from the hernial opening without serious injury. This not uncommonly occurs in the traumatic types of hernia and occasionally in esophageal hiatus herniae. In such instances, splenectomy is necessary.

In congenital herniae of infants, it is very important to remove carefully the herniated viscera from the thorax directly into the abdominal cavity and not permit the intestine to be exposed or injured with sponges any more than is absolutely necessary, as this adds a great deal to the shock of the operation. Great care should be exercised in carefully replacing the viscera in the abdomen so as not to produce a volvulus or interference with the blood supply.

After carefully replacing the viscera into the abdomen, the abnormal opening in the diaphragm is closed with interrupted silk sutures. In the case of adults, the tissues are first stabilized by interrupted silk sutures and then fascia lata which has been removed from the thigh, is interwoven between the overlapped layers and along the margin of the closure. The latter method is particularly advantageous in cases of traumatic herniae in which the diaphragm has been torn from the thoracic wall.

In all cases in which there has been a direct communication between the abdominal and the thoracic cavities, every effort should be made to reestablish the negative pressure within the pleural cavity by removing the air and by expanding the lung before the opening in the diaphragm is closed completely. In some instances, this cannot be accomplished until after the rent in the diaphragm has been closed. In some cases pneumothorax may push the mediastinum and heart to the opposite side and cause marked embarrassment of respiration and circulation. In these cases it is imperative that the mediastinum be stabilized in the midline immediately, by aspirating the air from the pleural cavity with a needle until the pressure becomes negative. I think it advisable to make a roentgenogram before the patient leaves the operating table, for the purpose of determining the amount of pulmonary expansion present.

Most patients are given a blood transfusion either during or immediately after the operation. The blood of every patient is grouped for transfusion before the operation. If the systolic blood pressure decreases to 90 Mm.Hg., or less, the patient should receive a transfusion of blood. I believe it is very important to maintain blood pressure at a fairly constant level and not permit it to drop more than 20 Mm.Hg. below the normal preoperative reading. I prefer the use of blood transfusions to the intravenous use of solutions to maintain the blood pressure. Blood transfusions are also advisable in all cases in which the hernia is associated with loss of blood that produces secondary anemia.

If there is excessive mucus in the bronchi and lungs at the time of operation, it is imperative that it be removed by aspiration through the intratracheal tube used for the administration of the anesthetic agent, or by the use of the bronchoscope before the patient leaves the operating table.

On removing the patient to his bed, which has been made warm by hot water bottles, external heat is applied to the patient by use of additional hot water bottles. Fifty-eight to 60 per cent oxygen is administered in an oxygen tent until the patient has fully recovered consciousness, and the administration is continued thereafter as indicated. After the patient has fully regained consciousness, the oxygen may be administered with a nasal mask.

RESULTS

The results of operation in this series of 304 cases of various types of diaphragmatic hernia, in which 283 of the patients were adults and 21 were children, were as follows: There were 15 deaths following operation in the

entire series, or an operative mortality of 4.9 per cent. Eleven deaths occurred among adults and four among children. Of the 11 deaths among adults, nine occurred after operation for esophageal hiatus type of hernia, one after operation for repair of hernia due to congenital absence of the posterior portion of the diaphragm, and the remaining one after operation for traumatic diaphragmatic hernia. The cause of death in these 11 cases was pneumonia and pulmonary edema in five, cardiac disease and coronary sclerosis in three, cerebral embolism in one, pulmonary embolism in one, and mesenteric thrombosis in one.

Of the 21 infants and children operated upon, four died. Three died after operation for pleuroperitoneal hiatus type of hernia, and one after operation for repair of congenital absence of the posterior portion of the diaphragm. These children were 7, 9, 18, and 24 months of age, respectively, and in all instances death occurred within 48 hours after operation. One child died at the time of operation soon after the opening in the diaphragm had been exposed but before the repair of the opening had been begun. The causes of death of the four children were respiratory and cardiac failure, with partial atelectasis of the lung.

There were nine recurrences, all of which occurred among adults who had esophageal hiatus types of hernia. Of these nine patients, five had no recurrence of symptoms and recurrences were diagnosed because of a small protrusion of the cardia of the stomach above the diaphragm. Three of these five patients had a moderate shortening of the esophagus before operation. In this type of hernia it is not uncommon to find a small portion of the cardia above the diaphragm following operation. This may not progress and reoperation is not indicated unless there is recurrence of symptoms. In the case of the remaining four patients there was a definite recurrence of the hernia and subjective symptoms. A second operation was necessary for complete relief of symptoms in three cases and partial relief in the remaining case. There were no recurrences following operation in any of the other types of herniation among adults, and no recurrences following operation in the case of any of the children.

Of the entire series of 304 patients who were operated upon for various types of diaphragmatic hernia, 289 recovered from operation; four of the 289 required a second operation before obtaining relief of symptoms.

Discussion.—Dr. Albert O. Singleton (Galveston, Texas): I was very glad that Doctor Harrington should make his maiden presentation before this organization on diaphragmatic hernia, a subject upon which he is such an outstanding authority. We have been in a quandary relative to the method of repair of some of these difficult herniae. In those about the esophagus in which there is an absence of diaphragm between the esophagus and aorta, a great deal of difficulty has been experienced. In two instances, we have transferred the esophagus further forward in its diaphragmatic penetration and closed the diaphragm behind the esophagus. In two cases of very large hernia in the anterior portion of the diaphragm, we have found it necessary to transplant a large patch of fascia from the thigh, and it has

functioned satisfactorily. We have also experienced a considerable degree of satisfaction in operating upon large diaphragmatic herniae, other than esophageal, through the thoracic approach, finding it much easier than through the abdominal approach. I should be very much pleased if Doctor Harrington would comment upon these points which I have mentioned.

DR. J. D. RIVES (New Orleans, La.): I should like to comment on one of the questions asked by Doctor Singleton. In the case of a very large defect such as he has described, it is quite likely that the best approach would be abdominal, because until exploration has been made it might well be impossible to determine the location and size of the opening in the diaphragm. This would not interfere in any way with the use of the procedure we have proposed for the closure of large defects in the anterior portion of the diaphragm, provided the exploration had been undertaken through a midline or a transrectus incision. I believe that the mobilization of the transversus abdominis would provide a well-vascularized sliding graft that would serve the purpose admirably, and it would be much simpler to do this than it would be to obtain a free graft from some other location.

DR. S. W. HARRINGTON (Rochester, Minn., closing): There is considerable difference of opinion among surgeons concerning the details of the operative technic for diaphragmatic hernia. Limited time did not permit me to discuss many of these technical problems.

Doctor Singleton has asked for discussion of two important technical considerations; namely, the type of approach to be utilized (whether through the thoracic or the abdominal cavity), and the method of closure of esophageal hiatus hernia caused by structural deficiency of the hiatus posteriorly.

I have used both the thoracic and abdominal methods of approach. I prefer the abdominal approach for all herniae through the left hemidiaphragm because when it is used I believe there is less risk of thoracic complications. For herniae through the right hemidiaphragm, I prefer the thoracic approach because the large right lobe of the liver interferes with exposure of the hernial opening. In some types of hernia, such as traumatic hernia and hernia due to congenital structural deficiency of the leaf of the diaphragm, the type of approach may be considered to be the surgeon's choice, because the defect usually is accessible for repair by either method. In the treatment of esophageal hiatus hernia, however, I believe that there are many fundamental advantages in utilization of the abdominal approach, because this type of hernia is sliding and does not enter the pleural cavity; rather, it enters the posterior portion of the mediastinum, behind or lateral to the pericardium.

Removal of the hernial sac or the attachments of the sac to the stomach is one of the important steps in the operative repair of these hernias. The attachments of the hernial sac to the stomach can be exposed only by the abdominal approach. The presence of any associated esophageal lesion, such as traumatic erosion or ulcer, or any injury to the herniated abdominal viscera occurring during the operation, can be recognized readily and treated, if necessary, through this approach.

The type of defective hiatus present can be determined, and hernia due to the posterior structural deficiency of the hiatus can be repaired with less risk of injury to spleen, aorta, and caudal lobe of the liver.

Another important technical consideration in the repair of posterior hiatal hernia, is interruption of the left phrenic nerve for elevation of the diaphragm, so that the opening can be closed around the esophagus at a higher level, since there is usually a moderate shortening or contraction of the esophagus

which elevates the cardia of the stomach. It is also important to imbricate several strands of fascia lata into the closure of the posterior margins of the hiatus. This procedure usually insures a very satisfactory and strong closure of this elevated position of the esophagus above the cardia. I have utilized this method of treatment of true congenital short esophagus of moderate degree, in which the surgical problem is not only repair of an enlarged hiatus but also elevation and reconstruction of the diaphragm above the cardia of the stomach.

As to the question of repair of anterior defects of the diaphragm, I may say that I have operated upon four patients who had presented large structural deficiencies of the muscle, and I obtained very satisfactory results by utilizing the fascia of the rectus muscle and reenforcing this with the round ligament of the liver.

BRIEF COMMUNICATION

INTRAMAMMARY HEMANGIOMA*

FRANK WARD SMYTHE, M.D.
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HEMANGIOMATA are not often found in the breast. Deaver and McFarland,[1] in 1917, summarized only 13 cases from the literature, dating back to 1837. Menville[2] found nine cases in 3,000 breast tumors, at the Johns Hopkins Laboratory. Bloodgood[2] said he, personally, had never explored one. Johnston,[3] during a 15-year period, at the University of Maryland Medical School, noted only one hemangioma in 666 breast tumors. In a six-year period, at the Skin and Cancer Unit of the New York Post Graduate Medical School and Hospital, there were 900 benign breast tumors. From these, Cholnoky[4] found nine hemangiomata. The records of the last 1,184 breast tumors admitted to the four largest hospitals in Memphis (John Gaston, St. Joseph's, Methodist, and Baptist Memorial) show four cases of hemangioma. Thus in a total of 5,750 cases, 23 hemangiomata were found, comprising a low percentage (.004 per cent).

The ratio of those occurring in females to males was 10.5 to one. Their ages at the time of examination varied from 11 weeks to 64 years, although most were between 20 and 40.

There are two types of breast hemangiomata: The capillary and the cavernous. The latter are more frequent. Most of the tumors are benign, although some are malignant. In 1928, Wright[5] states: "Malignant tumors of the blood vascular system, which metastasized to other parts of the body *via* the blood stream, are very rare. Less than one dozen of such proved cases have been reported." He separated these into two classes: (1) those with an apparently benign structure; and (2) those with a malignant one. He, further, believed that the structure in the metastases was always similar to that of the parent tumor. Robinson and Castleman[6] state "that only four authentic cases have been reported. Two of these were primarily in the breast" (Boormann's[7] and Ewing's[8]).

A few cases of metastasizing angiomata of the breast, having a malignant structure, have been reported: 11 angiosarcomata, by Schmidt[9]; one similar tumor, by Onsy[10]; and a malignant hemangio-endothelioma, by Menville.[2] Ewing[8] had seen only two metastasizing angiomata, and one of these was from the breast.

INSTANCES OF HEMANGIOMA OF THE BREAST OCCURRING IN THE MEMPHIS HOSPITALS

Case 1.—White, male, age 40. A hard, smooth, mobile mass, 2 cm. in diameter, in lower outer quadrant of left breast. No fixation, nipple normal, no drainage, no

* Read before the Southern Surgical Association, Pinehurst, N. C., December 9–11, 1941.

regional adenopathy, no pain, no history of trauma. *Clinical Impression:* Benign solid tumor. Operation in 1922. Excision of mass. *Pathologic Diagnosis:* Benign hemangioma. Result, no follow-up.

Case 2.[11]—White, female, age 32. A hard, rounded, smooth, mobile mass, 1 cm. in diameter, in lower outer quadrant of left breast, no fixation to skin, nipple normal, no discharge, no regional adenopathy, no pain, no trauma. *Clinical Impression:* Benign solid tumor. Operation October 29, 1940. Excision of mass. *Pathologic Diagnosis:* Benign hemangioma. Result, apparently cured to date.

Case 3.—White, female, age 59. A hard, round, smooth, mobile mass, 2 cm. in diameter, in lower outer quadrant of right breast, no fixation to skin, nipple normal, no discharge, no pain, no trauma, no regional adenopathy. *Clinical Impression:* Benign solid tumor. Operation December 8, 1940. Excision of mass. *Pathologic Diagnosis:* Benign hemangioma. Result, apparently cured to date.

Case 4.—White, female, age 18, seen April 21, 1938. A hard mass, about 6 cm. in diameter, in upper outer quadrant of left breast, borders smooth, outline irregular, mobile, no fixation to skin. Slightly tender on pressure. Nipple was normal. No discharge, regional nodes not palpable. Present for eight months. It was first noticed ten days before a normal menstrual period and a few days after a severe contusion. Three months later, after another trauma, the mass increased in size and beneath the skin was a purpuric discoloration. On two occasions small purpuric spots had been noticed over the opposite breast. However, repeated blood studies, including platelet counts, bleeding and coagulation times showed no evidence of a blood dyscrasia. Tourniquet tests were negative. *Clinical Impression:* Benign mass, probably traumatic fat necrosis. Operation April 22, 1938. Cautery excision of mass. *Pathologic Diagnosis* (frozen-section): Angioma.

On June 18, 1938, appendicectomy for an acute appendicitis.

December 19, 1938, apparently a reappearance of tumor in left breast. No palpable nodes. Roentgenogram of chest clear. Roentgenotherapy for reappearance. April 19, 1939, apparently cured. October 15, 1940, coughing and loss of weight. No mass felt in breast, no palpable nodes. Roentgenogram of chest did not show metastases. No cells were found in sputum. Symptoms continued. Further study of permanent sections gave the impression of malignancy. This was confirmed by Dr. James Ewing.[12] On November 30, 1940, roentgenograms revealed pulmonary metastases. In March, 1941, pulmonary symptoms aggravated. Nausea, headache and choked disks pointed to cerebral metastases. A downward course continued, in spite of palliative therapy, at Memorial Hospital, New York, and patient died June 21, 1941.

Autopsy.—Dr. F. W. Stewart:[13]

(1) Capillary angiosarcoma of left breast (no evidence of residual disease).
(2) Metastatic angiosarcoma to lungs, omentum, mesentery and both ovaries.
(3) Secondary hypoplasia of uterus.
(4) Atrophy and fat replacement of breasts.
(5) Anemia, probably secondary from hemorrhage into disseminated tumor metastases.
(6) Healed surgical wounds of breast and abdomen.

Pathologic Diagnosis.—Malignant metastasizing capillary angioma. Most of the nodules are hemorrhagic and partially necrotic through infarction.

Extreme atrophy of endometrium with cystic degeneration of nodes.

Marked hyalinization of splenic arterioles (possibly result of radiation)?

This rather complete summary of Case 4, permits three conclusions: (1) The frozen-section diagnosis was incorrect. (2) The reappearing primary tumor was sensitive to roentgenotherapy. (3) The metastases were *via* the blood stream.

Diagnosis of these tumors is not easy. They may be diffuse or circumscribed, smooth or irregular in outline, soft or hard. Pain may or may not be present. They may or may not be diminished in size on compression. Some pulsate, others do not. A bruit[14] may be heard. Transillumination is of no definite value. If the lesion is near the surface, there may be some discoloration or an infra-red photograph may prove of value.

Sherry[15] concluded: "A unilateral tumor of the breast that increases rapidly in size, decreases in size on compression, only to return rapidly on relaxation, and which may or may not have a bruit or thrill, should be suggestive. When the angiomatous tissue is present in the integument, this only adds to the certainty of the diagnosis."

For the treatment of hemangiomata, almost all methods of local attack have been used—injections of perchloride of iron, boiling water and, more recently, sclerosing solutions, electrolysis, actual cautery, roentgenotherapy, radium and surgery.

Operation is the best treatment—for the small tumor, a wide excision; for the large one, a mammectomy. With a very large and extremely vascular hemangioma of the breast, it might be advisable to administer roentgenotherapy before the operation.

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Discussion.—Dr. Bradley L. Coley (New York, N. Y.): Doctor Smythe has presented a case of extreme rarity. The records of the Memorial Hospital, which contain those of some 20,000 breast cases, show only one

other similar case. In reporting the essential facts of our case, it is hoped that further light may be shed upon this rare condition.

Case Report.—An unmarried Jewish female, age 22, was admitted to the Hospital for Special Surgery (formerly the Hospital for Ruptured and Crippled), August, 1925, complaining of a lump in the right breast. Three months previously she had been struck in the right breast by her sister's elbow; a blow had been sustained in the same breast two months prior to that. In the interval elapsing between these two injuries, a lump was noticed which had increased only slightly in size up to the time of admission. There was no history of mammary tumor in the family.

On physical examination, the lower half of the right breast was found to be about twice the size of the normal side. There was a purplish-colored, distinctly localized swelling below the nipple, which represented the encroachment of this mass on the skin. The mass was not so hard as carcinoma. It was thought that the growth was more characteristic of angiosarcoma or endothelioma. Except for the small purplish skin area described above, the rest of the skin was normal in appearance and texture.

Previous Treatment.—The patient's first medical adviser carried out local applications for two weeks without improvement. A surgeon was consulted, who made an incision into the mass. Following this operation the patient was assured that the mass would disappear. A month and a half later, the condition being no better, this surgeon advised another operation, which was performed, November 13, 1925, and which, apparently, consisted of removal of the mass by an incision from beneath the breast. A recurrence followed, which was treated by another physician who inserted radium needles, *i.e.*, nine needles left in place for two and one-half hours, over an interval of six weeks.

When first seen by me, June 29, 1926, there was an indurated area in the inferior quadrant of the right breast, involving the operative scar. This induration was movable over the chest, but the skin over it was not freely movable. Directly beneath the nipple area it was definitely fixed to the skin. There was no axillary adenopathy. A diagnosis of recurrent angiosarcoma was made, and an immediate radical mastectomy was performed. The raw area on the chest wall resulting from the wide skin excision was allowed to granulate, and it healed in six weeks. Thereafter a total of 16 roentgen ray treatments were administered to the axillae, right and left, in three courses given in July and September, 1926, and in January, 1927.

The pathologic diagnosis was that of malignant angiosarcoma. In December, 1926, a recurrence, about 2 cm. in diameter, was noted, and on December 14, 1926, an excision was carried out, and the area was covered with a full-thickness graft taken from the abdomen.

On January 5, 1927, there was roentgenographic evidence of metastasis in the left upper chest. Two months later the patient died, the whole course of the disease being less than two years.

It is interesting to speculate on what the outcome of this disease would have been had a prompt diagnosis been made, and a wide excision—or preferably complete removal of the breast—had been carried out. It is obvious that this tumor was highly malignant and metastasized by the blood stream. It was not apparently influenced by the radiation therapy, although 15 years ago the radiation methods were less effective than those in use to-day.

In retrospect, it would seem that this patient had an incision into the tumor. Then there was a delay of six weeks before excision of the tumor was carried out. Thereafter, a recurrence was treated by the insertion of radium needles which were allowed to remain for two and one-half hours. Finally, an adequate radical surgical procedure was undertaken, but evidently too late, and recurrence and metastases to the lungs eventually ensued.

A plea is made for earlier recognition of the condition and wide surgical removal.

BOOK REVIEW

Skin Grafting. By Earl C. Padgett, M.D.

The Charles C. Thomas Company have added another monograph to their library of vital and timely books on surgical problems with the contribution by Earl C. Padgett on the subject of "Skin Grafting."

The unusually high standard of craftsmanship which the Thomas Company has established is maintained, as was to be expected, and it makes the reading of the book not only easy, but a real inspiration to the younger surgeons of this generation who are beginning to appreciate the necessity for early and massive skin grafting in wounds of the soft tissues.

Although skin grafting is one of the oldest of surgical procedures, it was not until comparatively recent years that the surgical profession has employed it as we now know it should be done. In the preface, the author rightly gives credit to Blair and Brown for introducing, in 1929, the method of so-called massive split-grafts. This consists in the cutting of a graft considerably thinner than the old full-thickness or Tiersch graft, and somewhat thicker than the type of skin graft formerly used. That the ideal skin graft of such thinness as to secure successful transplantation, and leave the donor's site capable of spontaneous regeneration, can be almost routinely obtained with Padgett's dermatome is one of the outstanding contributions to surgical technic of the present time. With this instrument the inherent human factor and the impossibility of controlling absolutely the level of the hand-held knife are eliminated by the mechanical knife Padgett has devised. He has found that as a rule grafts cut by the hand method, even by the experienced, vary from .008 to .016 inch in thickness, while with the dermatome one can routinely remove a sheet four to eight inches in area and .020 to .024 inch thick, which insures the practical certainty of a take.

In addition, Padgett discusses in this monograph the other factors involved in a successful take, such as proper fixation, tension, hemostasis, pressure, and a clean granulating surface.

Surgeons who have followed Padgett's technic in using this instrument generally agree that the failures to take, which averaged 20 per cent or more of the full-thickness grafts in the past, have been practically eliminated.

It would seem that this is a book that should be in the library of every hospital and of every general surgeon who undertakes the responsibility of traumatic surgery.

Walter Estell Lee, M.D.

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